THE Petroleum Engineer

COMBINED EDITION

• Drilling and Producing • Refining and Petrochemical • Oil and Gas Pipelining

SEPTEMBER, 1953 • VOLUME XXV • NUMBER 10

GENERAL

Federal Control Can Flow Through Gas Lines A-37
Hayden W. Head

Aramco Operations A-55
V. S. Swaminathan

Features

Course of Oil A-4
Advertisers' Index A-6
With the Editors A-8
Highlights in Oildom A-10
Petrolic Personalities A-12
Meetings A-14
Letters to the Editors A-18
Petroleum Profile A-78
D. A. Hulcy
Women at Work E-1
Alva Ellisor, Lois Bailey, Margaret M. Feeney, Maxine Campbell, Pearl M. Dolan
General News E-6
General Personals E-14
Deaths E-18
The Petroleum Engineer's Continuous Tables E-21
(Installment No. 193)
Laugh With Barney E-36
Oil and Gas Trade News E-37
Trade Personals E-39
Books E-43
New Equipment E-47
Trade Literature E-52

DRILLING AND PRODUCING

South Dakota — Geology and Stratigraphy B-7
James L. Brown

Hydraulic Fracturing with Emulsion Stimulates Production B-14
M. A. Whitfield and C. H. Hutchins

Some Considerations in the Selection and Application of Sucker Rod Pumps B-38
Kenneth N. Mills

Experimental Basis for Neutron Logging Interpretation B-49
J. T. Dewan and L. A. Allaud

Observation of Water Damage to Oil Productivity B-56
T. A. Bertness

Tight Holes Are Poor Business B-68

Carthage Field Compressor System B-73
C. A. Brashear

Machine for Conditioning Mud B-80
Vernon B. Zacher

Performance of a Cypress Sand Flood B-86
Leon Krause

A Practical Application of Fluid Hydraulics to Drilling In California B-92
Gene D. Thompson

Features

Editorial B-3
Drilling and Producing News B-112
What's Doing in Drilling B-114
Exploration Activities B-118
Running Tour With Men in the Industry B-120

REFINING AND PETROCHEMICAL

Ammonia from Natural or Refinery Gases and Air C-3
Synthesis of Petrochemicals — 2
Arch L. Foster

Catalytic Polyforming of Gas Oil C-7
L. Berg, L. G. Mayfield, H. A. Saner, W. F. Polich, B. A. Ennenga, R. B. Hamilton, L. D. Lewallen, R. L. Crecelius

Plant Aids C-15
Repair Thread Leak

Trends in Refinery Instrumentation C-17
Part 11 — Liquid Level Measurement and Control
S. D. Ross and W. W. Drake

Switch Lamps Converted to Electric Operation C-25
E. B. Brien

Canada Makes Phenol, Acetone from Cumene C-27
Harry Chapin Plummer

Analytical Methods C-34
Continental's Tests for Determination of Per Cent Stable Oil and Tank Vapors Volume in Separator Oil C-34
Test for Presence and Evaluation of Product Soluble Rust Inhibitors C-35

New "Fluid Coking" Process Boosts Domestic Fuel Yields from Residual Oils C-38
Arch L. Foster

Largest British Refinery Building Rapidly C-41
A. E. C. Drake

Technical Forum C-44
Thixotropy in Greases

Features

Refining and Petrochemical News C-47
Refining and Petrochemical Personals C-56

OIL AND GAS PIPELINING

Remote Operation of Older Stations D-4
Dean Hale

West Coast's Largest Submarine Line Laid in Record Time D-7
Richard Sneddon

Development and Operation of an Underground Storage Program D-10
W. E. Ferguson

Teletype Service Expands Communications on Buckeye Pipe Line for More Efficient Operation D-25
J. D. McCullough

Measurement of Water Vapor in Natural Gas D-27
W. M. Deaton

Products Pipe Line in Operation D-36

Why Modernize?—A Short, Short Course in Economics D-40

Features

In This Issue D-3
Pictorial D-42
Pipe Line Personals D-46
Oil and Gas Pipe Line News D-51
Pipe Line Projects D-62
With the Pipe Line Contractors D-68

The PETROLEUM ENGINEER Publishing Company, Irwin-Keasler Building, DALLAS 1, TEXAS. T. J. CROWLEY, *President;* K. C. SCLATER, *Vice President and Executive Editor;* W. T. BRYAN, *General Manager and Treasurer.* **Editorial Staff**—FRANK H. LOVE, *Editor in Chief;* ERNESTINE ADAMS, *Managing Editor;* SIM H. CREWS, *Editor, Drilling and Producing;* ARCH L. FOSTER, *Editor, Refining and Petrochemical;* DEAN HALE, *Editor, Oil and Gas Pipelining;* RICHARD SNEDDON, *Editor, Pacific Coast,* 1106 B North Louise Street, Glendale 7, California. Phone Chapman 5-1951; EUGENE BRIEN, *Eastern Editor,* 52 Vanderbilt, New York 17, New York. Phone MUrray Hill 4-1890; MARY MORRIS LYMAN, *Assistant Editor.* **Advertising Staff**—T. J. CROWLEY, *President and Advertising Manager;* New York—JOE B. WOODS, 52 Vanderbilt Avenue, New York 17, New York. Phone MUrray Hill 4-1880; Chicago—E. V. PERKINS, 53 West Jackson Blvd. Chicago 4, Illinois. Phone HArrison 7-6883; Los Angeles—RICHARD P. McKEY, 465 East Union, Pasadena 1, California. Phone RY-1-8779; Dallas—ABBOTT SPARKS, Irwin-Keasler Building, Dallas 1. Phone STerling 4403; ABBOTT SPARKS, *Director of Promotion;* ED SEALY, *Promotion Manager;* ROYAL COURTNEY, *Circulation Manager.*

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Indexed by Industrial Arts Index and The Engineering Index, Inc.

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The Oil Industry and the 83rd Congress

Reflecting the importance of petroleum in the industrial picture of the nation, congress, in the 83rd session recently adjourned, by weight of legislation and debate, devoted more attention to this industry than to any other single subject. Such attention could be viewed either in a favorable or an unfavorable light. It could mean that the oil industry is a culprit of the first order and requires a disproportionate amount of our lawmakers' time to keep it in line. Happily this is not the case. It could also mean that because of the very great role played by petroleum in the national economy, it is deserving of every consideration that can be given it to cause it to function with greatest efficiency. From the nature of the legislation passed it is obvious that such is the majority viewpoint.

To summarize, the tidelands bill, possibly the most publicized piece of legislation, was passed to return to the coastal states title to offshore lands out to historic boundaries, three miles for most states and 10.5 miles for Texas and Florida. Beyond these limits title rests with the federal government and provision was made for leasing by the secretary of the interior of these lands in the Continental Shelf.

Further, emergency price and material controls were removed. The excess profits tax was extended, an unpopular move, but assurance was given that it would not be continued beyond December 31. Exploration for oil on the Naval Petroleum Reserve in Alaska was terminated. Proposals for extending operations in the Teapot Dome (Wyoming) were discarded. Government-owned synthetic rubber plants were ordered sold. Could these last several items indicate a trend toward taking the government out of business?

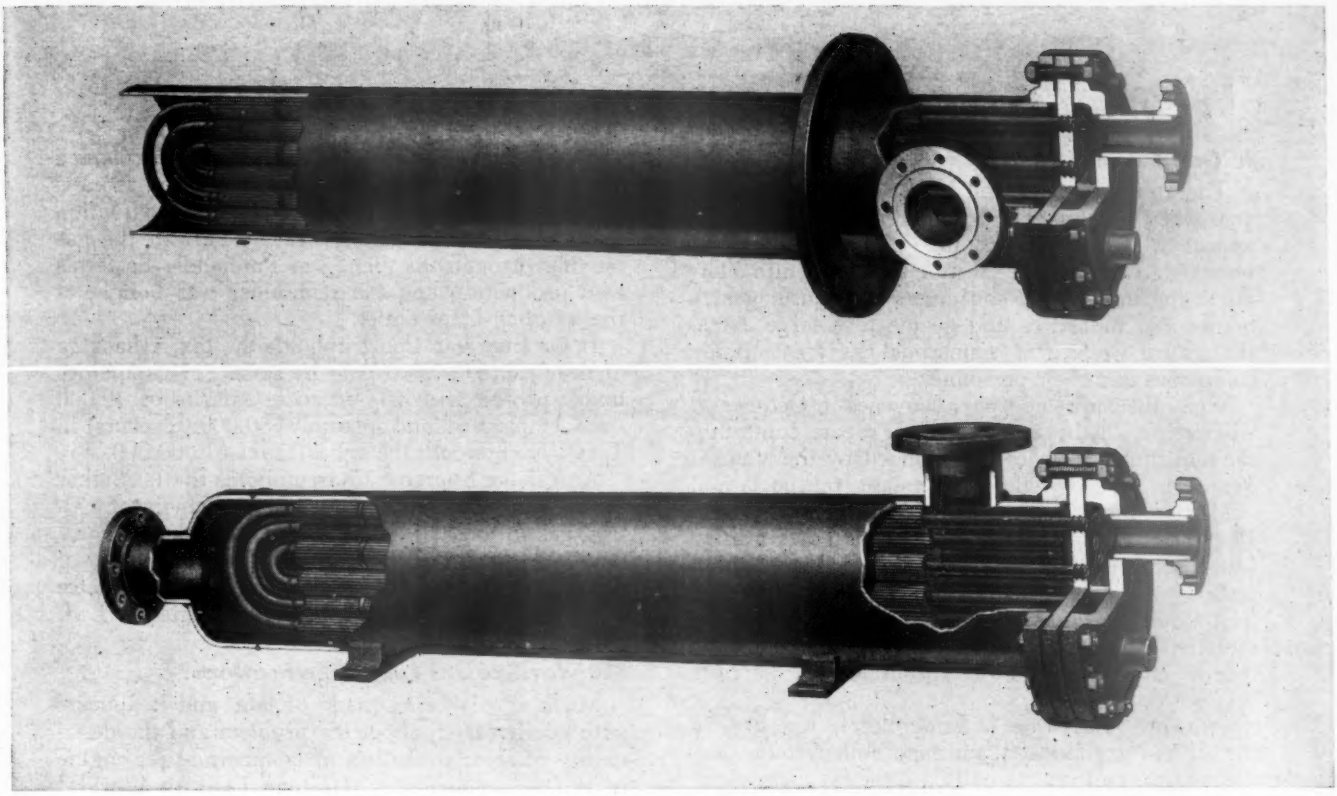
A previous ruling of the department of the interior was revoked when natural gas pipe lines crossing public lands were declared not to be common carriers. Mining claims for fissionable materials filed prior to January 1, 1953, on public lands already leased for oil and gas were authorized.

These are some of the more important matters that have occupied the attention of congress, but, numerous as they are, many problems have been carried over to the next session for their solution. Among them are: The "oil cartel" case, modified to a civil action on recommendation of the president, with hope for dismissal by reason of a new study to determine the scope of the anti-trust laws; what, if anything, is to be done about imports; whether the government should interest itself more or less in synthetic fuels, and the possibility of transferring oil and gas authority to the department of commerce.

There is also the matter of price investigation. Although it is not generally considered likely that legislation will result, the industry cannot afford to assume a complacent attitude. Already through this medium proration and the depletion allowance have been brought under question. The latter, in fact, is now being studied by the U. S. treasury department as it prepares recommendations on taxes to be presented before the next session of congress.

For the most part legislation passed by the 83rd Congress was of a favorable nature; however, the oil industry, always fair target for barbs of politicians, cannot permit itself the luxury of being caught off guard. As the Irish political leader, John Philpot Curran said: "Eternal vigilance is the price of liberty."—F.H.L.

XUM



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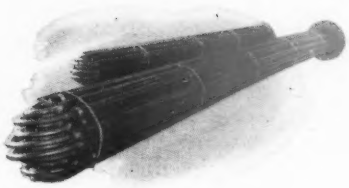

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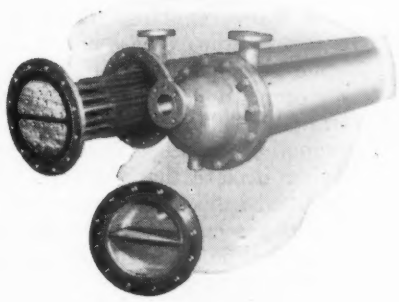

Hairpin Bundle Assembled in Shell Showing Mounting of Tube Sheet Between the Shell and Head.

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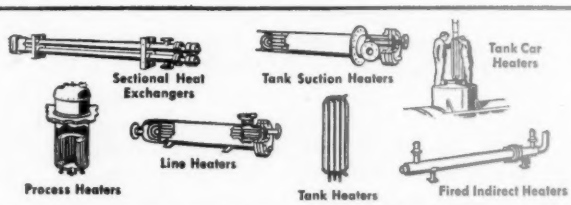

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XUM

With the EDITORS.....

Is Gas Tax Justified?

The autumn season will barely be underway this year when the United States Supreme Court, upon an appeal by two natural gas pipe line companies, will be asked to decide on a question that could ultimately affect the millions of consumers of natural gas in homes and industries and decide to a large extent the future welfare of numerous gas transmission companies and their personnel.

When the Supreme Court convenes in October, it will decide whether or not to hear a case contesting the constitutionality of a tax levied by the state of Texas on gas received for interstate transportation.

Making the appeals are the Michigan-Wisconsin Pipe Line Company and Panhandle Eastern Pipe Line Company. The two companies filed companion suits against the tax, in Travis County 126th District Court in Texas on the basis that the tax is a violation of the so-called commerce clause of the federal constitution, which prohibits tax barriers between the states.

Outcome of the case is being closely watched by the oil and gas industry and many other states producing gas. To the state of Texas, the tax means millions of dollars in potential revenue. Many other states have expressed a desire for similar taxes on gas produced and shipped interstate.

The amount of the tax, which is 0.45 cent per 1000 cut ft, is not a large amount. Applied against billions of cubic feet produced and moving out of Texas daily, it comes to a very large sum.

But, the pipe line companies point out, it is not the amount of the tax, but the principle behind it. Should the Supreme Court uphold the tax, the states could eventually increase the tax to such a rate that it would be prohibitive to take gas from Texas and move it to other markets.

In their appeals, the pipe line companies have noted that the burden of the tax ultimately would be borne by consumers of the gas who are situated in other states, enabling Texas to achieve increased revenues at the expense of citizens of other states.

State officials in Texas have defended the tax as an "occupational levy," imposed equally and uniformly on "all persons engaged in such business or occupation, whether interstate or intrastate." The officials declare that the pipe line companies have benefitted from other Texas laws, namely the state's oil and gas conservation laws. Without such laws, the natural gas pipe line companies could not exist, the officials declare.

Answering, the pipe line companies point out that the gas is lawfully produced and, like any other commodity, is a lawful article of commerce.

The right to transport gas to other states, which necessarily includes the right to take possession of it for such transportation, is not derived from the state.

"That right arises under and is protected by the commerce clause (of the Constitution). It may not be taxed by the state 'no matter how specious may be the pretext' for imposing the tax."

In the initial phase of the court tests, the district court held for the pipe line companies and ordered the state comptroller to return the tax money collected with interest. The appeals court later reversed this decision.

To the district court Panhandle Eastern explained that the tax was levied on gas purchased from a Phillips Petroleum Company gasoline extraction plant in Hansford County, Texas. Part of the gas moving through the plant was Panhandle Eastern's own production and the remainder was bought at the gasoline plant outlet.

If the Supreme Court upholds the tax, a backlog of nearly $18,000,000 paid by some 117 companies under protest will help increase salarits of 40,000 state employees and possibly 50,000 teachers in Texas. Each month the tax is about $1,000,000.

And if the Supreme Court upholds the tax, other states may adopt similar levies. Consumers of natural gas in most of the 48 states may eventually be paying more for their fuel, with possibly much of the increased cost by many consumers in many states going to support government of a few states.—D. H.

Standardize Jet Fuel Specifications?

Much ado is being made of late, and it appears with good reason, about the problem and the desirability of standardization of commercial jet engine fuels. One commentator (Ogstone, Esso Air World), points out that the large oil companies are in position to supply most any type of fuel wanted, and these companies are not concerned as to the nature of the fuel adopted by jet engine operators.

Multiplicity of grades of fuel have always been a thorn in the side of the oil refining and the fuel users' industries, especially the refiners. The greater the number of individual fuel specification the refiner must meet, inevitably the greater the cost to the buyer as the refiner's costs go up. Pointing to the undoubtedly increased costs for piston-engine fuels, due to a needlessly large number of different fuels manufactured, it is urged in the case of jet fuels that this penalty be avoided by deciding on the specifications of a suitable fuel for general and wide use in commercial jet engines.

Three considerations must govern the choice of fuel type: Availability, cost, and the technical suitability of the fuel for engines in operation. Like the diesel engine the jet engine *can* use a wide variety of fuels, but as its efficiency improves the fuel requirements are most stringent. The problems of safety from fire hazard in jet planes, of ignition properties, of vapor lock in plane tanks in flight, all must be considered. As to fuel costs, quotations show prices ranging from 17 cents for 100-130 aviation gasoline to 7½ cents for heavy marine diesel fuel. In estimating over-all fuel costs, reported to be 30-45 per cent of the total operating cost for a jet-powered transport, the costs for a given "trip" range from $2432 with aviation fuel at 27 cents per gallon delivered to the plane, to $1664 for JP-4 fuel, to $1250 for heavy marine diesel fuel.

It is believed to be in the best interests of user and refiner alike that commercial air lines should agree on a single grade of jet fuel, to be adapted to all jet engines. This means careful study of all the controlling factors in fuel properties and availability. The matter is aided, informed men agree, if the fuel so adopted is one already in wide distribution, to cut costs and speed up supply. — A. L. F.

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HIGHLIGHTS IN OILDOM

Texas Oil Allowable Cut

Texas is producing 119,691 bbl of oil per day less this month than last, the biggest cut in allowable production since July 1952, when the Texas Railroad Commission struck 164,017 bbl per day off the permissible flow.

Maximum allowable was set at 3,005,443 bbl a day. Reduced production will come about by a shortened daily producing schedule. The state generally will be allowed to produce 19 days and East Texas fields 18 days. Reason for cut was given as less demand, and revised figures of requirements submitted earlier.

Buffalo People Eat Buffalo

Buffalo Oil Company, true to its name, ate buffalo at its annual barbecue in the Maljamar, New Mexico, district recently. The buffalo was purchased by the company and half was prepared in Artesia and half sent to Tulsa for consumption at that district's barbecue.

Congress Studies Oil

Although Congress is still in session a solution to several problems concerning the oil industry will still be sought. Last month the House Ways and Means Committee heard testimony and received written statements concerning the percentage depletion allowance of the petroleum and other industries. Another committee, headed by Senator George W. Malone, R., Nevada, began hearings this month on the availability of fuels, including oil, and the Department of Justice is still studying the recent price rises.

Simpson Bill Killed

The House has killed the so-called Simpson bill, which was designed to increase tariff protection for U. S. industry and agriculture. The vote backed up President Eisenhower, who had opposed it as conflicting with the Administration's foreign trade program. Should the bill have passed it would have set up tight import restrictions on crude petroleum and residual fuel oil. The State Department reported the cut back quota for residual fuel oil would cut back imports to only one-third of recent imports and would particularly affect New England area which depends on such imports for its power.

Mining Bill Up

Legislation is pending to permit uranium miners to continue operation on oil and gas land in the Colorado plateau area. The Senate and the House had agreed to the bill validating the improper mining claims and protecting the rights of oil and gas lease holders. Two amendments were attached to the House version of the bill, however. These amendments protect the authority of the Atomic Energy Commission to issue leases to uranium miners.

T. J. Crowley Is President Of The Petroleum Engineer

T. J. Crowley has been elected president of The Petroleum Engineer Publishing Company, filling the vacancy created by the recent death of W. L. Love.

Crowley has been prominent in oil publishing circles for the past 35 years and formerly was vice president in charge of advertising, for *The Petroleum Engineer*.

The following editorial changes have also been announced:

K. C. Sclater, widely known petroleum engineer and author, and former editor-in-chief has assumed the post of executive editor.

Frank H. Love has been appointed editor-in-chief. Love has been with The Petroleum Engineer for 22 years in various editorial positions, and was previously editor of *The Petroleum Engineer's* "Oil & Gas Pipelining" edition.

Dean Hale, an Oklahoma A&M graduate, has been named editor of *The Petroleum Engineer's* "Oil and Gas Pipelining" edition. He was previously with the Oklahoma Publishing Company, Oklahoma City, and is a member of the ASME and AIIE.

Oil Demand Estimate Up

The Bureau of Mines has changed its prediction of oil demand in the U. S. for 1953 to 8,118,000 bbl daily for the year. This is up 5.2 per cent from 1952, including exports of 386,000 bbl daily, down 11 per cent, and a domestic demand of 7,732,000 bbl daily, up 6.2 per cent. Bureau officials said the strong domestic demand reflected increased highway consumption. A 6.6 per cent increase in motor fuel, and a substantial gain in aviation gasoline bore out this statement.

OWIU Official Questioned

Former publicity director of the Oil Workers Union (CIO) and author of the OWIU's history was called before the McCarthy Committee on July 14. In testimony he refused to answer the committee's question as to whether he had ever been a Communist and claimed his constitutional privilege (Fifth Amendment) to do so.

OIIC Film in Edinburgh

For the second time an Oil Industry Information Committee movie is being shown at the Edinburgh Film Festival this fall. The movie is "Man on The Land." "Twenty-four Hours of Progress" was shown at an earlier festival. "American Frontier" is the 1953 OIIC movie, soon to be released.

Mossadegh Steps Down

Taking up the responsibility of head of his country, the Shah of Iran reports that country is desperately in need of funds to help it survive. He said he would accept help from anyone right now. The unhappy Mossadegh has surrendered to the army of Premier Fazollah Zahedi. After a nine-hour coup that cost approximately 300 lives and perhaps will cost more, Mohammed Mossadegh dejectedly and weakly limped into the Central Tehran officers' club to hand over the reins of his country after his near-dictorial rule. The Shah of Iran, who had fled to Rome when first attempts to overthrow Mossadegh failed, returned in triumph to Iran where he will rule with the new premier. What diffierence this will make in the Iranian oil situation with Britian remains to be seen, however, General Zahedi is described as being friendly with the U. S. though anti-British.

In Washington Russell Brown, general counsel of the Independent Petroleum Association of America, speaking on the possibility of resumption of Iranian oil production, stated, "The return of Iranian oil to world markets would seriously aggravate the already existing threat of foreign oil surpluses."

Insurance for Gasoline

A new insurance policy, designed to sell more gasoline, has been introduced into some parts of California. Called the Tebco Insurance Premium Plan the policy is operated by Tebco Inc. This is the way it works. The motorist gets a form from the filling station attendant keeping a small piece of the form for the attendant to punch each time he buys gasoline. After the form is filled out it is sent to Tebco for filing. When the motorist has bought 150 gal of gasoline, and his receipt has been punched the proper amount of times, he sends the receipt to Tebco and in return gets a $500 auto accident medical expense policy good for four months. Tebco spokesmen admit that a legal stipulation makes this type policy non-renewable, but claim termination date of one policy can jibe with effective date of a suceeding policy.

Truce Effect on Oil Slight

Cessation of hostilities in Korea have made very little if any change in industry, businessmen report. If there is any let down in the military consumption of petroleum products, it is expected to be temporary and slight. The continuing need to build up stocks in the event of a national emergency is also expected by some industry leaders to take the place of any drop in oil consumption in Korea. Colonel Douglas Brown, director of the Armed Services Petroleum Purchasing Agency, reported that a temporary lull in military oil demand may result but he expected the demand will rise again.

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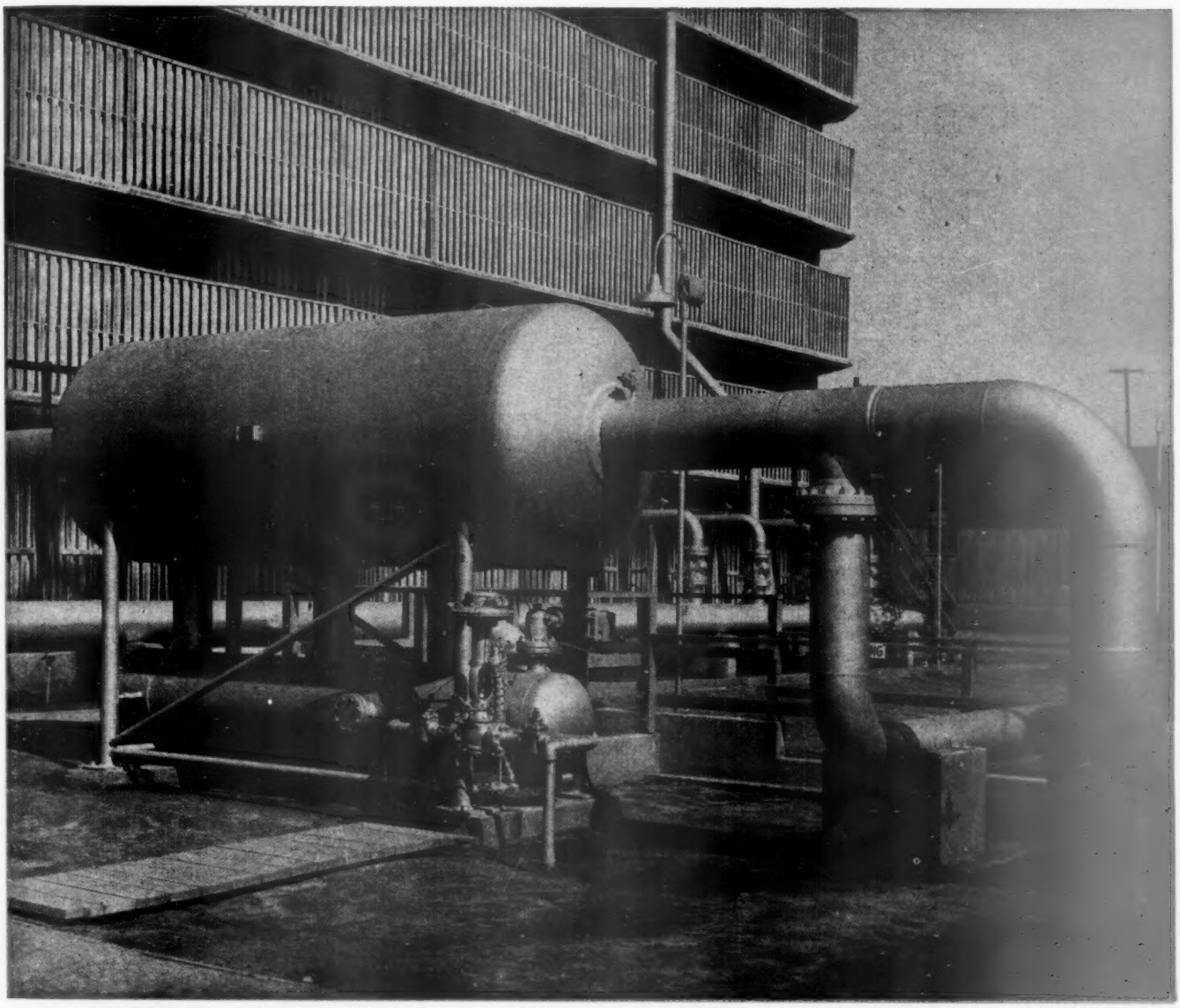

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PETROLIC PERSONALITIES

DICK SNEDDON

NOMADS SAIL OFF INTO THE WILD BLUE

One of the greatest voyages of discovery since Amundsen sailed the Northwest Passage, was the recent junket of the Los Angeles chapter of Nomads into the uttermost recesses of Long Beach Harbor. Hosted by that amazing octogenarian, Frosty Martin, chairman of the Harbor Commission, a sizable stash of Nomads began assembling at the Pacific Coast Club in the early afternoon and before the whingding was over, a total of ninety sat down for dinner.

At about 2:30 p.m., the early ones were picked up by bus and whisked to and about a bewildering series of piers, warehouses, and construction projects, after which they boarded a lugger or a tender or something and viewed it all again, only more so, from the seaward side. It was a pretty imposing journey during which they were fed an entertaining assortment of pertinent facts and satistics by Al Maddy, executive secretary of the harbor, Eloi "Frenchy" Amar, general manager of the port, Frank Hardisty, chief petroleum engineer, and Bob Metzger, the public relations chap.

We, personally, arrived on the scene in the early afternoon, and in no time at all had run afoul of Roland Smith, erstwhile president of the L. A. Nomads, and Ray Elliott, president of Elliott Manufacturing Company, sometimes known as the Mayor of 108th Street. Presently we were joined by John Flanagan, the M. O. Johnston export manager, whom it is always good to meet, and pretty soon we were practically engulfed in Nomads and the friends of Nomads.

IS "UBIQUITOUS" A NASTY WORD?

Among them at various times during the day we spotted Jim Hughes, the erudite chapter prexy from Lane Wells, and Mort Higgs and Murray Walker, another pair of estimable ambassadors from the same estimable establishment. Then there were Jack Ballagh, the Pierpoint Morgan of the equipment business, and his guest, Hugh Dierker, a hotshot divot lofter from the Wilshire Country Club; Hans Ross, the genial Baash-Ross executive and big game hunter—a big game of gin rummy is what he is usually hunting; Hi Cassidy, the oratorical smoothie, and his guest Tim McCarty, a pair of astute Hibernians from one of the better known advertising agencies in our village; Earle Boggess, the Baker Oil Tool Company exporter, and natator extraordinary; Knight Templeton, the golfing whiz from the S. R. Bowen Company; Don Grubbs, the Oilwell Supply Company head man and a lovely partner for one who is given to dabbling in the speculative enterprises; Elmer Wycoff, the National Tube biggie, to whom we apologize profusely for describing him in a previous number as "ubiquitous."

The word is really flattering but Elmer hasn't looked it up yet and he still thinks we were giving him what is commonly known as "the business." We also exchanged a bit of chit-chat with Waldo Moore, a lad whom we shall always remember kindly as one of those who first befriended us when we arrived in the U. S. from Canada, just after the War of the Roses, and his boss, Paul Cavins who was our roommate with the late Bob Block on the Nomad train to the Tulsa Oil Show about five or six years ago.

AT BEDTIME THEY COUNTED SHEEP

Among the guests from foreign parts were Haroldo da Silva and Johnson Bennett of Drillex in Brazil; Miguel Baca, Santa Fe Drilling Company, Peru; Vernon Clayton, C. M. White, and K. G. Long, Iraq Petroleum Company; P. K. Ozinga, Shell of Venezuela; Cope Johnson, Servicio Thomas, Venezuela; H. G. Goethe, Deutsche Erdoel A. G., Hamburg, Germany; and Bob Bryan, Santa Fe Drilling Company, Kuwait.

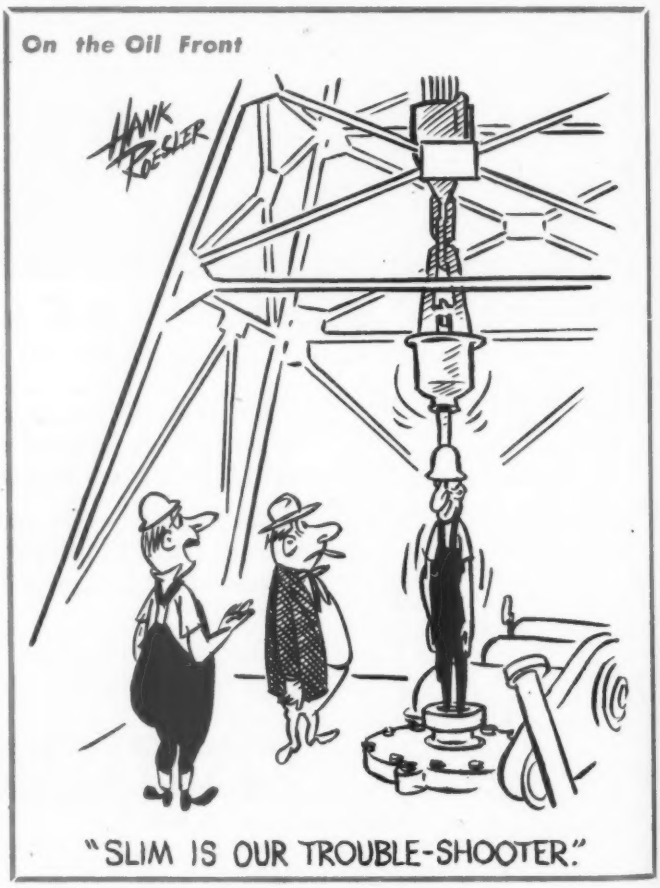
Also present were interesting domestic guests, as follows and to-wit: G. Otis Danielson and J. W. Bacom, Kerr and McGee Industries, Oklahoma City, Oklahoma; Bill Faulk, the young engineer who was largely responsible for the design of Shell Oil Company's ultra modern automatic trap farm at Brea, California; A. A. Ashton, LeRoy Newcomb, and A. H. Miller, a trio of eminent Emsconians; Phil Renn of Oil Base, Inc.; John Dickmann of Baash-Ross; and R. L. Engstrom of Hydril.

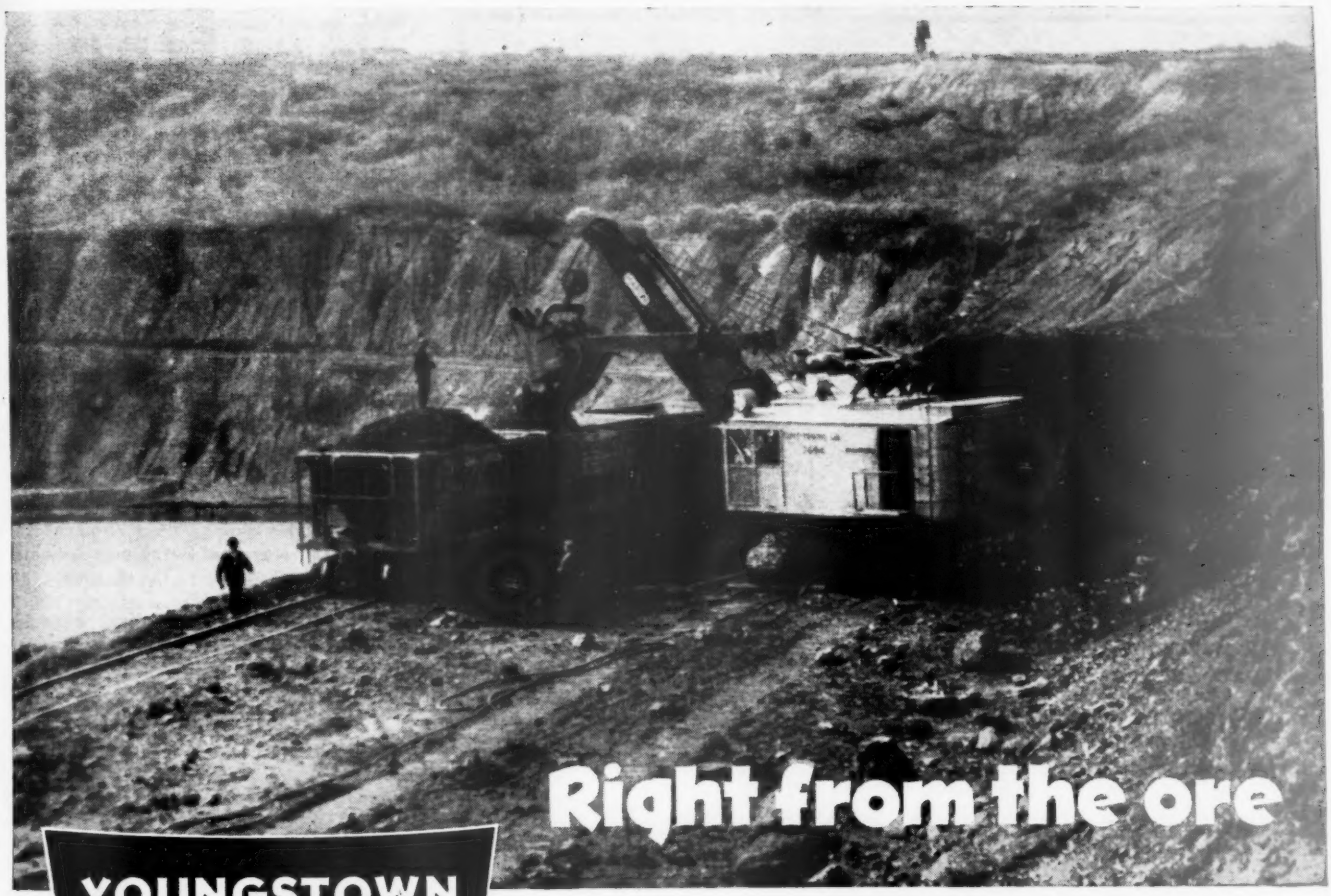
All of these thoroughly enjoyed the brief visit with Frosty and his associates down at the Long Beach Harbor, and after hearing Frenchy Amar's closing dissertation on sheep and their place in the economy of many nations, must have left for home feeling that the day had been well spent.

OF THE OTTUMWA ORACLE AND OTHERS

Others with whom we shot the petrolic breeze were Lou Bronzan, the Adel Precision veep, and one of founders of PPP; Bill Althouse, the friendly Baker Oil Tool Company redhead, and his boss, Ted Sutter, one of the Nomad founders and a power in PESA; Dick Winder, the Chiksan higher-up and a well regarded chap in oil and equipment circles; Hearn Paschall, the Pico Tool Company organizer, with a couple of his cohorts—W. Drayer and Merkle Johnston; Don Hall, Jack McCullough, and Harry Hester, a trio of right reputable lads from McCullough Tool Company; Elmer Decker, the Ottumwa oracle who took a lot of the guess out of drilling with his weight indicators;

Harry Morehouse and Bob Gaylord, a couple of high class citizens from the Wagner Morehouse works; Babe Doyle, the pioneer Angeleno and domino sharpie, representing Hydril, and Rex Collins, a younger but nonetheless capable attache of the same honorable house; Bob Craig, the tall, bashful, but altogether competent National Supply Company engineer; Fritz Ripley of the Ripley Waterman enterprises and another title tosser of whom the timorous should certainly beware; Jack Smith, the much traveled B-J export representative and a very pleasing after-dinner speaker we have noted.





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Electric Weld
LINE PIPE

Uniformly satisfactory in service because—

Long lengths save time and trouble

Weldability is outstanding

It bends readily

Line up characteristics are excellent

QUALITY YOUNGSTOWN SERVICE

RIGID QUALITY CONTROL

●One important reason why Youngstown Electric Weld Pipe is so uniformly satisfactory is that its production is under the sole supervision of a single integrated organization—from mining the ore to shipping the finished product.

Youngstown Electric Weld Pipe for the oil and gas industry is being made in sizes up to 22″ OD and in grades as high as X52. For further information, phone or write our nearest District Sales Office.

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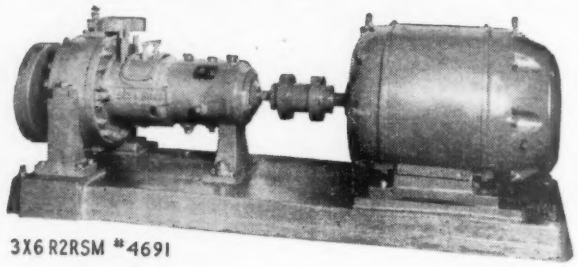
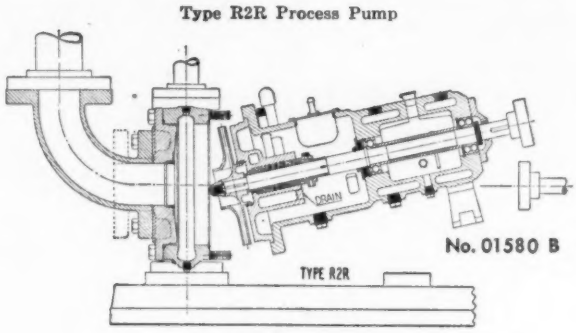
DEAN BROTHERS PUMPS INC.

Type R2R Centrifugal Process Pumps



Type R2R Process Pump



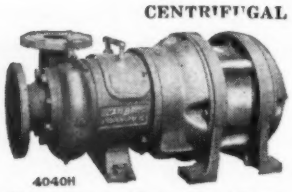
Type R2R Process Pump

DISASSEMBLY: The Type R2R process pumps can be disassembled without disconnecting the suction and discharge piping. By first removing the spacer from the spacer type coupling, and unbolting the casing from the cradle the entire cradle and complete rotating element can be removed without disturbing the suction and discharge piping.

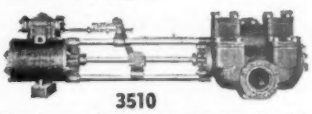
OPERATING RANGE: Type R2R, Heavy duty, process pumps are available in eighteen different sizes, enabling our engineers to furnish units specially designed and constructed for the particular work to be performed.
Capacities: 50 to 2000 Gallons per minute. Heads: Up to 400'. Speeds: 900 RPM to 4000 RPM.

BUILDERS OF OUTSTANDING PUMPS SINCE 1869

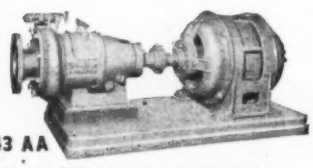
CENTRIFUGAL AND RECIPROCATING PUMPS



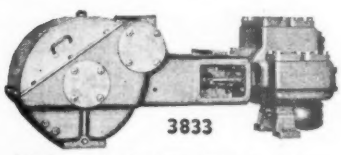
Close Coupled Centrifugal Pump



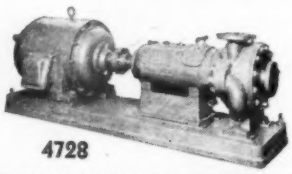
Horizontal, Single Style, Double Acting, Piston Type, Close Clearance Pump. Designed to handle volatile liquids



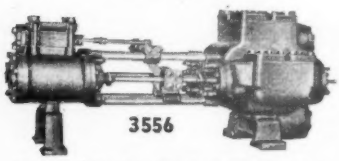
Pedestal Mounted Centrifugal Pump



Horizontal, Duplex, Double Acting, Side Pot, Piston Type, Oil Bath Power Pump



Double Pedestal Bearing Centrifugal Pump



Durable Duplex Packed Piston Pattern Steam Pump, Side Pot Type

ESTABLISHED 1869

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Meetings

Sept. 6-11—**American Chemical Society,** national meeting, Conrad Hilton Hotel, Chicago, Illinois.

Sept. 9-11—**Oil Industry Information Committee,** Cleveland Hotel, Cleveland, Ohio.

Sept. 9-11—**Pacific Coast Gas Association,** San Francisco, California.

Sept. 10-11—**Desk and Derrick Clubs of North America,** second annual convention, Cosmopolitan Hotel, Denver, Colorado.

Sept. 10-11—**Natural Gas Transmission Saftey Association,** semi-annual safety conference, Cortez Hotel, El Paso, Texas.

Sept. 13-16—**American Institute of Chemical Engineers,** Fairmont and Mark Hopkins Hotels, San Francisco, California.

Sept. 15-16—**American Petroleum Institute,** Executive Committee, Greenbriar Hotel, White Sulphur Springs, West Virginia.

Sept. 16-18—**National Petroleum Association,** annual meeting. The Traymore, Atlantic City, New Jersey.

Sept. 21-22—**Natural Gasoline Association of America,** Fractional Analysis Seminar, Texas Hotel, Fort Worth, Texas.

Sept. 21-25—**Instrument Society of America,** 8th national instrument conference and and exhibit, Sherman and Morrison Hotels, Chicago, Illinois.

Sept. 24-25—**Western Petroleum Refiners Association,** regional meeting, Henning Hotel, Casper, Wyoming.

Sept. 27-30—**American Society of Mechanical Engineers,** annual petroleum engineers conference, Rice Hotel, Houston, Texas.

Sept. 27-Oct. 2—**American Society for Testing Materials,** committee D-2 on petroleum products and lubricants, Shoreham Hotel, Washington, D. C.

Sept. 29.—**National Petroleum Council,** Washington, D. C., 10 a.m.

Oct. 1-2—**Mid-Continent Oil and Gas Association,** Louisiana-Arkansas division, annual meeting, Roosevelt Hotel, New Orleans, Louisiana.

Oct. 2—**Southern Gas Association,** conference on Right of Way problems, Memphis, Tennessee.

Oct. 4-6—**American Association of Oil Well Drilling Contractors,** annual meeting, Denver, Colorado.

Oct. 5-7—**Texas Mid-Continent Oil and Gas Association,** annual meeting, Rice Hotel, Houston, Texas.

Oct. 5-7—**Petroleum Electric Power Association,** 25th anniversary meeting, Hotel Muelbach, Kansas City, Missouri.

Oct. 7-9—**National Association of Corrosion Engineers,** South Central Region annual meeting, Mayo Hotel, Tulsa, Oklahoma.

Oct. 8-9—**California Natural Gasoline Association,** 28th annual fall meeting, Ambassador Hotel, Los Angeles, California.

Oct. 8-9—**Illinois Institute of Technology,** conference on Industrial Hydraulics, annual meeting, Hotel Sheraton, Chicago, Illinois.

Oct. 10—**American Institute of Chemical Engineers,** Oklahoma Statewide All Day Meeting, College High School, Bartlesville, Oklahoma.

Oct. 8-11—**First International Engineers' Congress,** fostered by the Federation Internationale des Associations Nationales d'Ingenieurs, c/o A.N.I.A.I., via Terme Diocvleziana, Rome, Italy.

Oct. 11-17—**Oil Progress Week.**

Oct. 19-20—**Independent Petroleum Association of America,** annual meeting, Hotel Texas, Fort Worth, Texas.

Oct. 19-21—**American Institute of Mining and Metallurgical Engineers,** Petroleum Branch fall meeting, Adolphus and Baker Hotels, Dallas, Texas.

Oct. 19-23—**National Safety Council,** annual congress, Conrad Hilton, Congress, Morrison, Hamilton Hotels, Chicago, Illinois.

Oct. 22—**American Institute of Chemical Engineers,** Hotel New Yorker, New York, New York.

Oct. 22-23—**Western Petroleum Refiners Association,** regional meeting, Garrett Hotel, Eldorado, Arkanasas.

Oct. 23.—**Natural Gasoline Association of America,** Southern Regional meeting, Blackstone Hotel, Tyler, Texas.

Oct. 26-28—**National Lubricating Grease Institute,** annual meeting, Edgewater Beach Hotel, Chicago, Illinois.

Oct. 26-29—**American Gas Association,** annual conference, Kiel Auditorium, St. Louis, Missouri.

Oct. 27—**Association of Consulting Chemists and Chemical Engineers, Inc.,** 25th Anniversary, Hotel Belmont Plaza, New York, New York.

Oct. 28-30—**Pennsylvania State College,** 17th technical conference on Petroleum Production, sponsored by Division of Petroleum and Natural Gas, Pennsylvania State College in cooperation with the Pennsylvania Grade Crude Oil Association, Mineral Industries Building, Pennsylvania State College, State College, Pennsylvania.

Oct. 29-31—**Rocky Mountain Oil and Gas Association,** annual convention, Cosmopolitan Hotel, Denver, Colorado.

Nov. 2-4—**Society of Automotive Engineers,** National transportation meeting, Conrad Hilton Hotel, Chicago, Illinois.

Nov. 2-4—**American Petroleum Credit Association,** 29th annual conference, Biltmore Hotel, New York, New York.

Nov. 2-6—**American Institute of Electrical Engineers,** fall general meeting, Hotel Muehlbach, Kansas City, Misosuri.

Nov. 3-4—**Society of Automotive Engineers,** national diesel engine meeting, Conrad Hilton Hotel, Chicago, Illinois.

Nov. 5-6—**Society of Automotive Engineers,** national fuels and lubricants division, Conrad Hilton Hotel, Chicago, Illinois.

Nov. 9-11—**The Geological Society of America,** annual meeting, Royal York Hotel, Toronto, Ontario, Canada.

Nov. 9-12—**American Petroleum Institute,** annual meeting, Conrad Hilton Hotel and Palmer House, Chicago, Illinois.

Nov. 12—**American Petroleum Institute,** Executive Committee, Conrad Hilton Hotel, Chicago, Illinois.

Nov. 19—**National Industrial Conference Board,** Schenley Hotel, Pittsburgh, Pennsylvania.

Nov. 20—**Natural Gasoline Association of America,** Panhandle-Plains Regional meeting, Herring Hotel, Amarillo, Texas.

NOMADS TO MEET

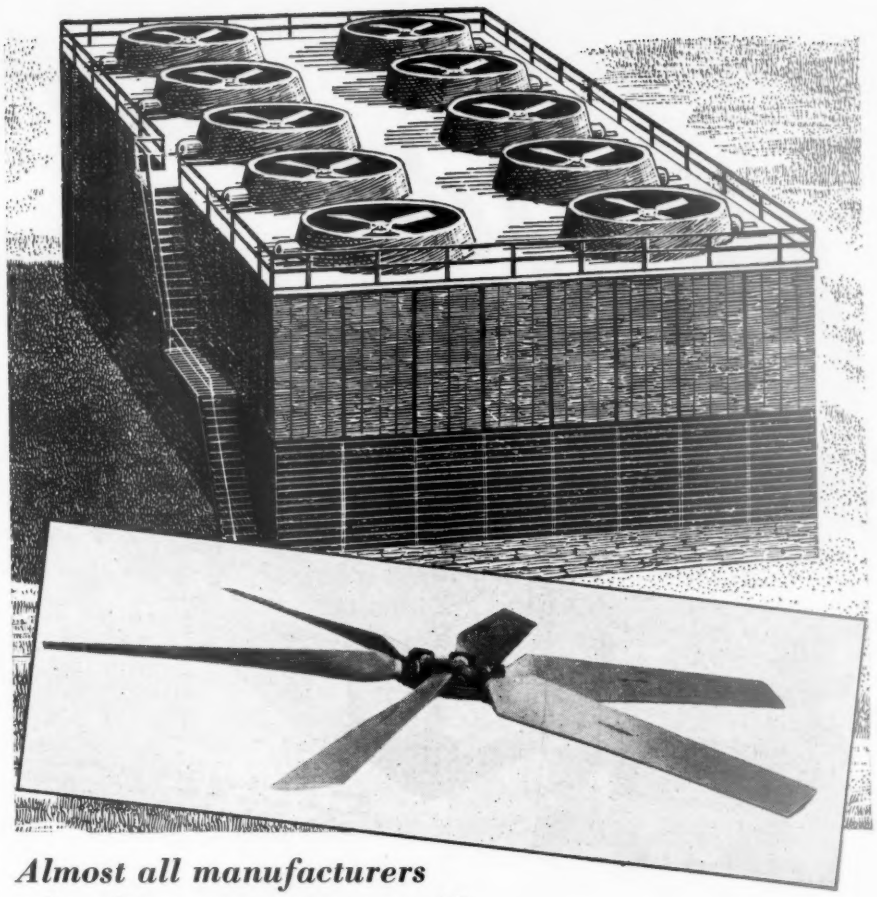
New York, N. Y., Chapter, First Monday of the Month, Louis Sherry's, New York. Secretary, O. B. Latrobe.

Houston Chapter, Second Monday of the Month, Ye Olde College Inn, Houston, Texas. Secretary, Harry E. Estes.

Los Angeles Chapter, Second Wednesday of the Month, Jonathan Club, Los Angeles, Calif. Executive Secretary, Wallace A. Sawdon.

Tulsa Chapter, Third Friday, "After Five" Room, Hotel Tulsa. Secretary, Gilbert Swift.

Dallas-Fort Worth Chapter, Dallas, Texas. First Monday of the Month. Secretary, M. W. Hiltpold.



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Cooling towers, air coolers, cooling and condensing units—whatever your installation, Aeromaster Fans give you more cooling at lower cost! The reason is Aeromaster's unique two-way service.

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In drilling literally millions of feet of hole, Unit Rig and Equipment Company's popular model U-15 Drilling Rig proves the dependability of Twin Disc Drives. The number of these Unit "work horse" Rigs in the field is approaching 500—with their power *effectively* put to work through Twin Disc Drives. All Unit Rigs of this basic design are equipped with three E or EH-218 Twin Disc Friction Clutches. And the latest versions have *additional* Twin Disc power linkage . . . are being offered with Twin Disc 21" or 27" HUD Hydraulic Disconnecting Couplings on the engine compound.

Unit recently completed its 480th rig of the U-15 design, incorporating Twin Disc Drives. Such production testifies to the wide acceptance of this model . . . and of the nearly *1,500 Twin Disc Friction and Hydraulic Drives—on this model alone.*

Built for a Long Life . . .
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REG. U. S. PAT. OFF.

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

BRANCHES: CLEVELAND • DALLAS • DETROIT • LOS ANGELES • NEWARK • NEW ORLEANS • SEATTLE • TULSA

Nov. 29-Dec. 4—**American Society of Mechanical Engineers,** Statler Hotel, New York, New York.

Nov. 30-Dec. 5—**Exposition of Chemical Industries,** 24th biennial run, Commercial Museum and Convention Hall, Philadelphia, Pennsylvania.

Dec. 6-8—**Chemical Specialties Manufacturers Association, Inc.,** annual meeting, Mayflower Hotel, Washington, D. C.

Dec. 13-16—**American Institute of Chemical Engineers,** annual meeting, Hotel Jefferson, St. Louis, Missouri.

Dec. 28-29—**American Chemical Society,** Division of Industrial and Engineering Chemistry, 1953 Symposium, University of Michigan, Ann Arbor, Michigan.

1954

Jan. 11-15—**Society of Automotive Engineers,** annual meeting and engineering display, Sheraton-Cadillac and Statler Hotels, Detroit, Michigan.

Jan. 18-22—**American Institute of Electrical Engineers,** winter general meeting, Statler Hotel, New York, New York.

Jan. 21-22—**American Industrial Conference Board,** Astor Hotel, New York, New York.

Feb. 26—**Natural Gasoline Association of America,** Permian Basin Regional meeting, Lincoln Hotel, Odessa, Texas.

March 3-5—**American Petroleum Institute,** Southwestern District, Rice Hotel, Houston, Texas.

March 8-10—**American Institute of Chemical Engineers,** Statler Hotel, Washington, D. C.

March 15-19—**National Association of Corrosion Engineers,** annual meeting, Kansas City Municipal Auditorium, Kansas City, Missouri.

March 17-19—**American Petroleum Institute,** Division of Production, Mid-Continent District, Skirvin Hotel, Oklahoma City, Okla.

March 25—**National Industrial Conference Board,** Ambasasdor Hotel, Los Angeles, California.

March 25-26—**New England Gas Association,** Statler Hotel, Boston, Massachusetts.

April 8-9—**American Petroleum Institute,** Division of Production, Rocky Mountain District, Townsend, Gladstone and Henning Hotels, Casper, Wyoming.

April 12-15—**Society of Automotive Engineers,** national aeronautics meeting, Statler Hotel, New York, New York.

April 21-23—**Natural Gasoline Association of America,** annual convention, Baker Hotel, Dallas, Texas.

May 2-4—**Independent Petroleum Association of America,** midyear meeting, Cosmopolitan Hotel, Denver, Colorado.

May 3-5—**American Petroleum Institute,** Lubrication Committee, Skytop Lodge, Skytop, Pennsylvania.

May 6-7—**American Petroleum Institute,** Pacific Coast District, Division of Production, Statler Hotel, Los Angeles, California.

May 10-12—**American Petroleum Institute,** Division of Transportation, Products Pipe Line Conference, Warwick Hotel, Philadelphia, Pennsylvania.

May 10-13—**American Petroleum Institute,** Division of Refining, mid-year meeting, Rice Hotel, Houston, Texas.

May 10-13—**Liquefied Petroleum Gas Association,** annual convention, Conrad Hilton Hotel, Chicago, Illinois.

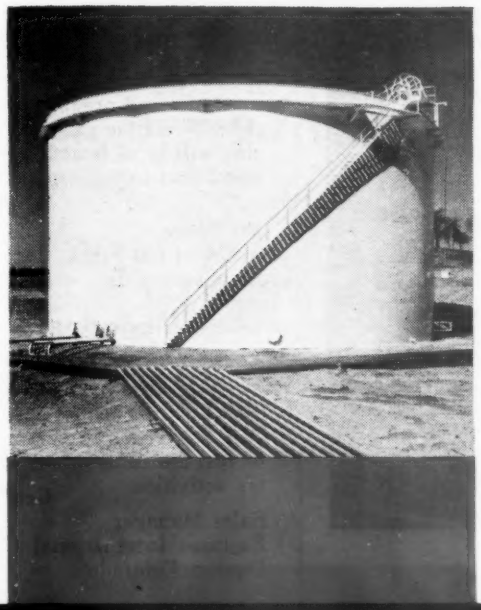
May 16-19—**American Institute of Chemical Engineers,** Conrad Hilton Hotel, Chicago, Illinois.

June 17-19—**American Petroleum Institute,** Division of Production, Eastern district, Greenbrier Hotel, White Sulphur Springs, West Virginia.

Sept. 12-16—**American Institute of Chemical Engineers,** Colorado Hotel, Glenwood Springs, Colorado.

the important factors in **floating roof design**

number 3 of a series

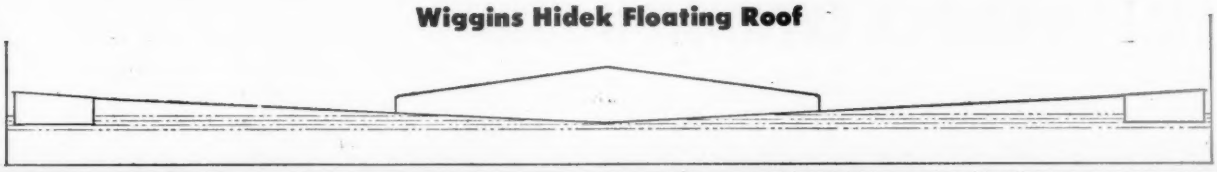


complete, clean drainage

The complete, clean drainage of Wiggins Floating Roofs assures year-round protection against paint peeling, rusting, and dangerous accumulation of water.

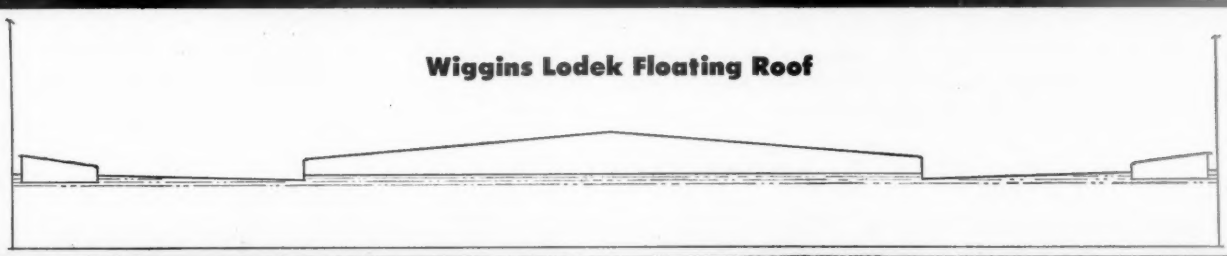
Wiggins Floating Roofs drain quickly—drain clean—because, they have the steepest pitch of all floating roofs. The patented Wiggins drains are designed to handle loads up to 6″ per hour rainfall. Radial plates with radial welds prevent puddles from forming.

Wiggins Hidek Floating Roof



Only Wiggins floating roofs meet every important design specification

Wiggins Lodek Floating Roof



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GENERAL AMERICAN
TRADE MARK

Other Vital Wiggins Conservation and Safety Features

Triple Seal Protection
- Exclusive primary, secondary and top seals provide the most effective protection against vapor loss.

Pontoons
- Divided into multiple *gas-tight* compartments for safety
- Deep and roomy, uncluttered with framework—for easy inspection, maintenance and repair

Strength
- Special Wiggins design gives optimum strength with the least amount of precious steel—better than normal safety factor

Capacity
- You get top-to-bottom use of tank capacity

GENERAL AMERICAN TRANSPORTATION CORPORATION

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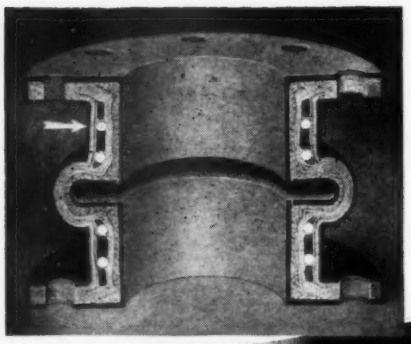

LEFT: Sectional view showing sturdy construction of a Garlock single arch spool-type expansion joint. Arrow points to one of steel reinforcing rings.

BELOW: Garlock 204 spool-type rubber expansion joint installed on a 30" pipe line connecting a propeller-type circulating water pump at the N. Y. State Electric & Gas Corp., Greenidge Station, Dresden, N. Y. The water temperature varies from 33° F. in the winter to 75° F. in the summer.

Forget about pipe line expansion and contraction due to temperature changes . . .

INSTALL GARLOCK EXPANSION JOINTS

Garlock rubber expansion joints relieve stresses and strains in pipe lines and connected equipment. These flexible joints absorb vibration and compensate for linear expansion and contraction of the line. In short, they greatly reduce maintenance costs on piping and connected equipment.

Garlock rubber expansion joints are used in central power stations, factory power plants, pumping stations, paper and pulp mills, ships, etc. They are made in all pipe sizes from ¾" to 72", round, rectangular, tapered, off-set, spool-type, and U-type. Neoprene expansion joints for oil service and "Teflon" expansion joints for chemical service are available.

CHECK THESE 8 ADVANTAGES:

1. Made of high-grade rubber, they do not crack or fracture under repeated flexing.
2. They do not take a permanent set.
3. For pressures up to 125 p.s.i. (depending upon size of joint); and for vacuum of 30 in. of mercury.
4. Suitable for operating temperatures up to 180° F.
5. They do not corrode or erode.
6. They are light in weight and can be installed in a limited space.
7. They require no gaskets between the flanges of the joint and the flanges of the pipe.
8. They do not induce electrolysis.

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GARLOCK

PACKINGS, GASKETS, OIL SEALS,
MECHANICAL SEALS,
RUBBER EXPANSION JOINTS

LETTERS

Finds Information Beneficial

To The Petroleum Engineer:

We wish to subscribe to *The Petroleum Engineer* for the National Oil Field Mud Distributors, Inc. Subscription is to be mailed to Mr. Robert A. Ainsworth, Jr., chief counsel for the newly formed organization. We feel that the information gained from your magazine will be of benefit to both Mr. Ainsworth and to our organization.

E. R. Albert, Jr.
President
National Oil Field Mud
Distributors, Inc.

Likes Magazine

To The Petroleum Engineer:

We . . . congratulate you and your staff for the excellence of your publication, which it not only informative but of real aid to us in our varied oil industry activities.

George J. Kruse
Sales Manager
Eastman International Company
Denver, Colorado

Wants "Areas of Promise"

To The Petroleum Engineer:

I should like to subscribe to *The Petroleum Engineer*, Drilling and Producing edition. I should also like to have a copy of the publication, "More Areas of Promise" which you had on display at the oil show in Tulsa, Oklahoma.

H. Marvin Douglass
Geologist
Champlin Refining

Alaska as Petroleum Area

To The Petroleum Engineer:

Increased interest in Alaska as a petroleum province has resulted in the intensifying of our program of petroleum investigations, particularly in suthern Alaska. Mr. Don J. Miller is the key geologist in this program. I know you will be happy to learn that a portion of his time this winter will be occupied by the preparation, with other geologists, of a Geological Survey Circular on the geology of those areas in Alaska believed to hold some potential for oil. This is planned for publication in the near future.

Ernest H. Lathram
Acting Chief
Alaskan Geology Branch
Geological Survey
San Francisco, California

Wants Oklahoma Data

To The Petroleum Engineer:

Would greatly appreciate your latest publication on Drilling and Producing practices. In addition, kindly enclose any brochures you may have with respect to oil fields in Oklahoma.

R. E. Williamson, Jr.
M. W. Kellogg Company

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are most efficient by any comparison!

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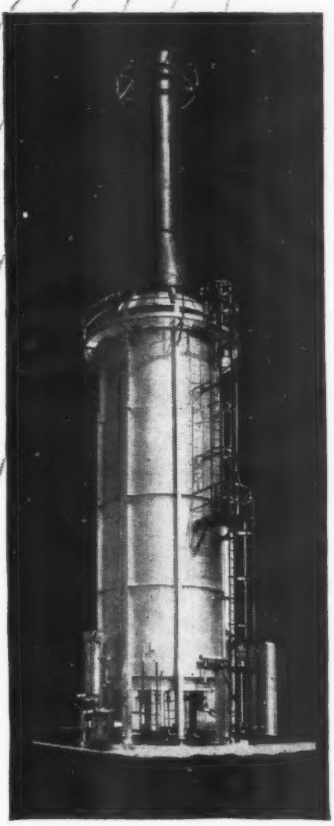
LOW MAINTENANCE
ZERO AIR LEAKAGE
EXPLOSION RESISTANT
MINIMUM GROUND SPACE
SHORT LENGTH OF LIQUID TRAVEL
EXCESS DRAFT FOR HIGH OVERLOAD
PLENUM CHAMBERS FOR HAZARDOUS AREAS

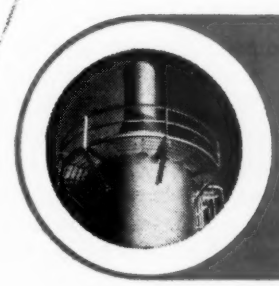


simplicity of design and construction

The Isoflow Heater basically is a circular steel shell; this results in an explosion-resistant structure. The shell is lined on the inside with insulation and insulating refractories; this results in a wall with a zero air leakage and high efficiency. The vertical tubes are combined with integral convection tubes; this results in less headers in the heaters for complete cleanability. The integral radiant convection tubes and minimum number of headers result in a minimum pressure drop for a given velocity. The vertical tubes completely shield the walls resulting in low wall maintenance. The small number of headers in combination with the vertical tubes result in ease of cleaning and, if desirable, gang-cleaning of several tubes simultaneously. Individual burners, symmetrically spaced with relationship to the tubes, results in even heat distribution horizontally. The reradiant cone effects even heat distribution vertically. Segregated burners result in ease of firing and inspection of burners. These are some of the design features which place Isoflow Furnaces in a class of their own

—most efficient by any comparison.

More than 1150 are in operation throughout the world in the petroleum, chemical and allied industries . . . for all processes and for any duty, pressure, temperature and efficiency . . . and all Petrochem-Isoflow Furnaces are pre-eminently satisfactory.



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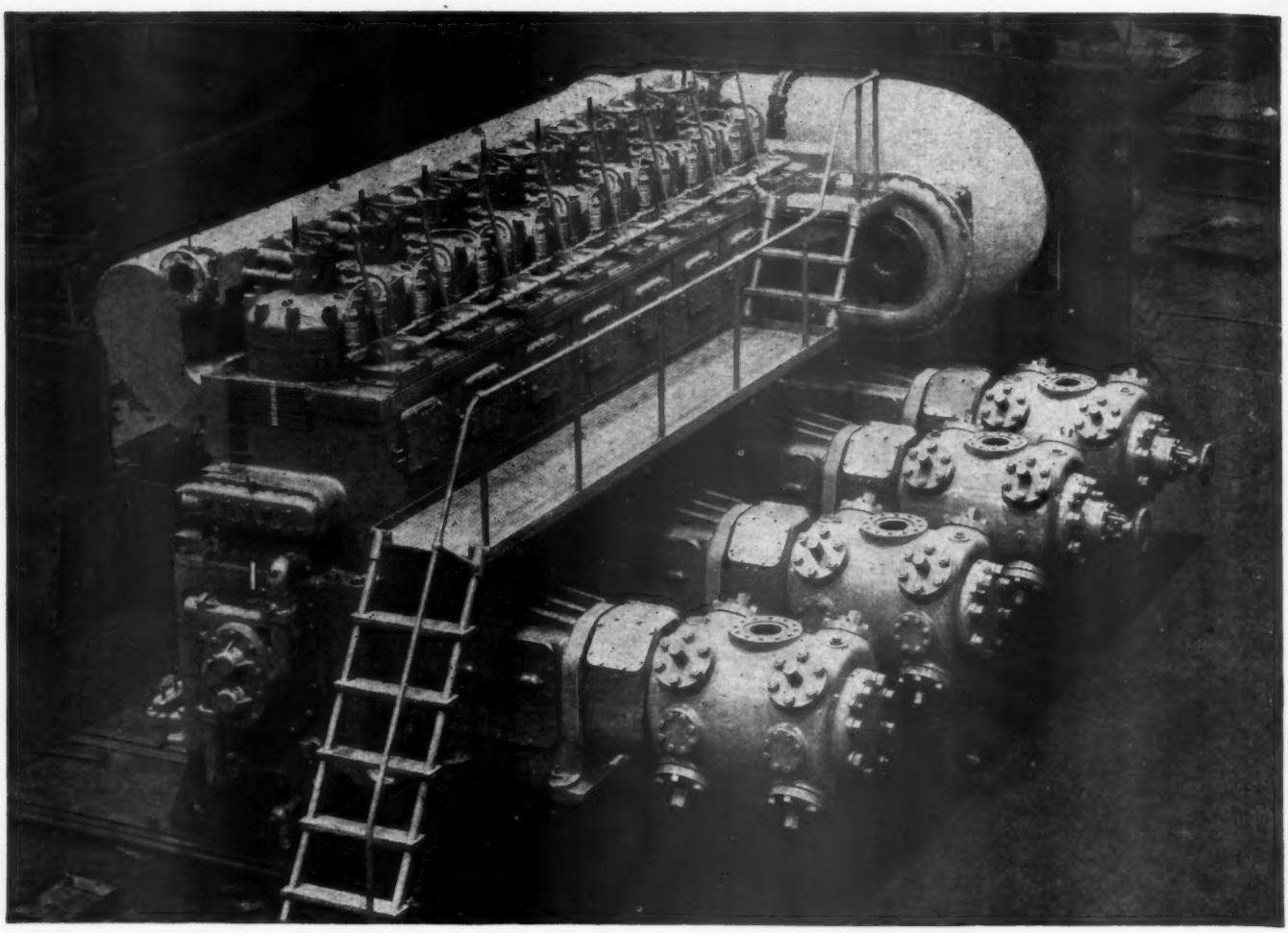


Clark 2-Cycle Turbocharged "Right Angle" Heralded As Most Significant Development In Compressor History

Revolutionary changes in gas-engine-driven compressor design set new records for power (50% increase), fuel economy (10-15% decrease) and cooling water load (25% decrease)

THE recently developed Clark 2-Cycle Turbocharged Right Angle Compressor has set new, industry-wide standards for power and operating economies, reports Clark Bros. Co., Olean, N. Y.

Climaxing an intensive 7-year Clark development program, the availability today of this completely new, turbocharged compressor design provides the realistic and ready answer to increasing cost of gas, inadequate cooling water supply in certain areas and the need for more powerful, more compact units. Clark engineers list the following points in support of these claims:

50% More Power

Fifty percent (50%) more power is delivered than by any previously built non-turbocharged unit of comparable bore and stroke (without any encroachment on overload carrying ability). The stepped-up power output means reduced building, foundation, piping and maintenance costs as well as decreased operating personnel.

10-15% Less Fuel Consumed

Conservatively rated, the new Clark unit is guaranteed to burn 10 to 15% less fuel than the best non-turbocharged, high compression, gas-engine-driven compressor previously built.

25% Less Cooling Water Load

Cooling water requirements per bhp are twenty-five percent (25%) less than those of the best non-turbocharged, high compression, gas-engine compressor previously built (including scavenging air

intercooling duty). This is important not only in arid locations, but means fewer cooling towers, smaller pumps, smaller piping and smaller motors to drive water pumps.

Flat Fuel Consumption Curve

Fuel consumption remains practically constant between seventy percent (70%) of load and maximum load, assuring optimum fuel economy over the entire operating range.

Quiet Operation

Energy, formerly lost in noise, is now harnessed for useful work by the Clark Turbocharger. This, plus a fully insulated exhaust manifold and en bloc construction, make it the quietest, smoothest operating gas-engine-driven compressor ever built. There are no exhaust pulsations.

UNITIZED, MATCHED DESIGN

Both turbocharger and compressor were designed and built by Clark as matching components. The result, say Clark engineers, is a highly efficient, unitized and integrated design.

The Turbocharger

The Clark turbocharger combines many of the design principles of Clark radial inflow turbines, combustion gas turbines and centrifugal compressors.

As applied to the new Clark Compressor, turbocharging is a practical means of converting waste heat into energy. It utilizes the waste heat, velocity and mass flow of the exhaust gases to drive a radial inflow turbine. The turbine, in turn, is integrally connected to a centrifugal compressor impellor which pumps air to scavenge the power cylinders and to furnish air for combustion. No scavenging cylinders are used or required.

At start-up and on light loads, the turbocharger is direct driven through a gear train from the engine crankshaft. Under all other load conditions, the turbocharger operates independently of the engine, its speed automatically conforming to the load placed on the engine.

Because the Clark turbocharger operates at very conservative speeds and temperatures, no critical, scarce materials are required for its construction.

The Compressor

While the gas-engine-driven compressor is an entirely new unit, specially designed to match the characteristics of the new Clark turbocharger, it retains many of the basic Clark "Angle" design features. Clark engineers describe it as the most rugged compressor ever built, "with a very conservative BMEP rating for a unit of its proportions."

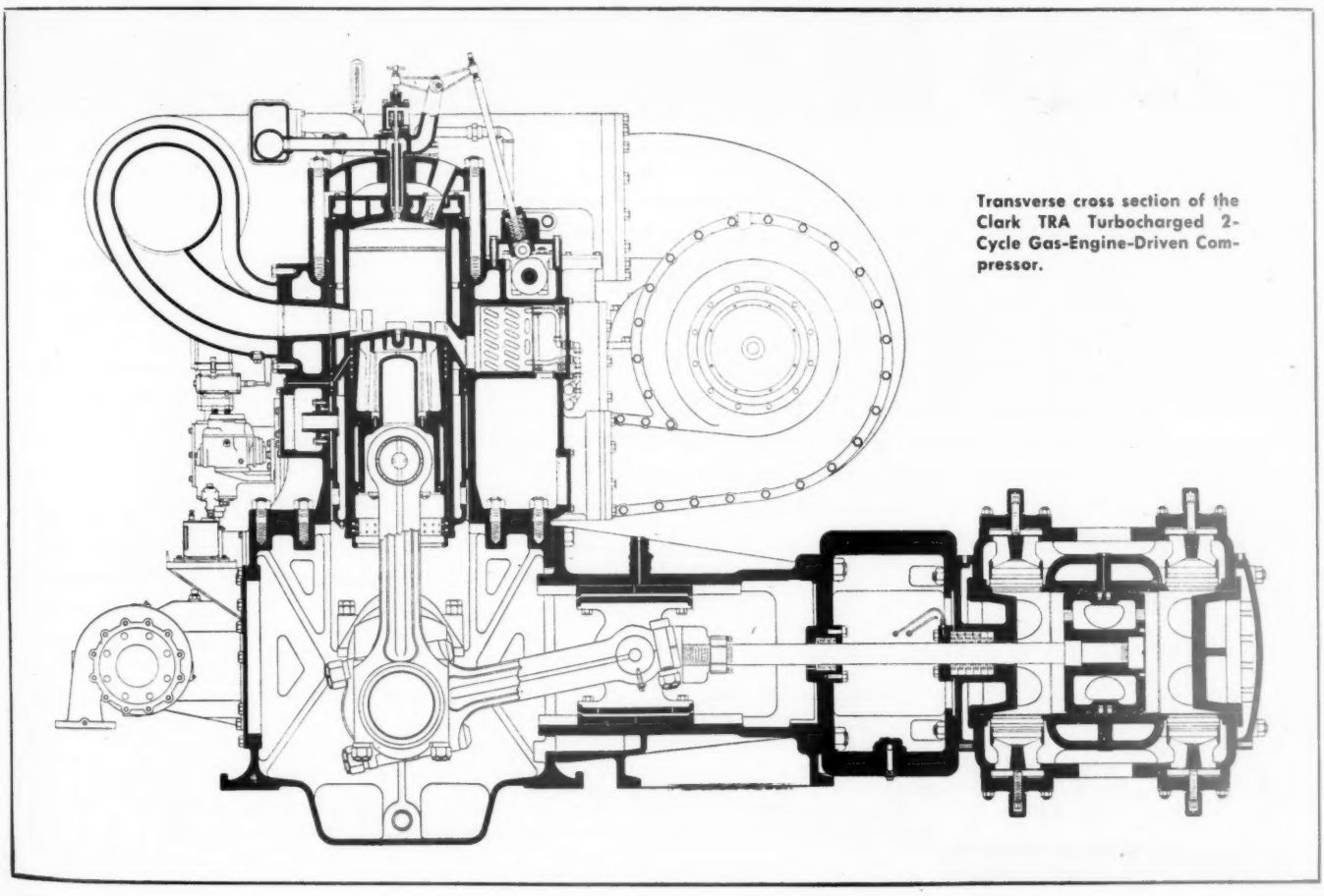
Following a long established Clark practice, the new compressor is an extremely compact, yet highly accessible 2-cycle, in-line design. It occupies considerably less space per bhp than non-turbo-charged units, because of its increased power output. Featured are: Cylinder block construction with removable power cylinder liners; full precision bearings; one-piece forged steel crankshaft; oil-cooled power piston heads and skirts; heavy, forged steel connecting rods; fully insulated, streamlined exhaust system.

MODELS

The Clark Model TRA-8, illustrated, has eight vertical in-line power cylinders of 14″ bore and 14″ stroke, developing 1320 bhp. Other size turbocharged units also are available.

Bulletin 130, with complete information on the Clark 2-Cycle Turbocharged Gas-Engine-Driven Compressor is obtainable from Clark Bros. Co., Division of Dresser Operations, Inc., Olean, N. Y.

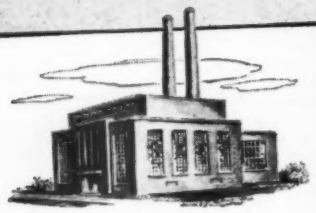
Clark manufactures a complete line of heavy duty compressors: motor driven; gas, steam and Diesel engine driven; centrifugal and axial flow.

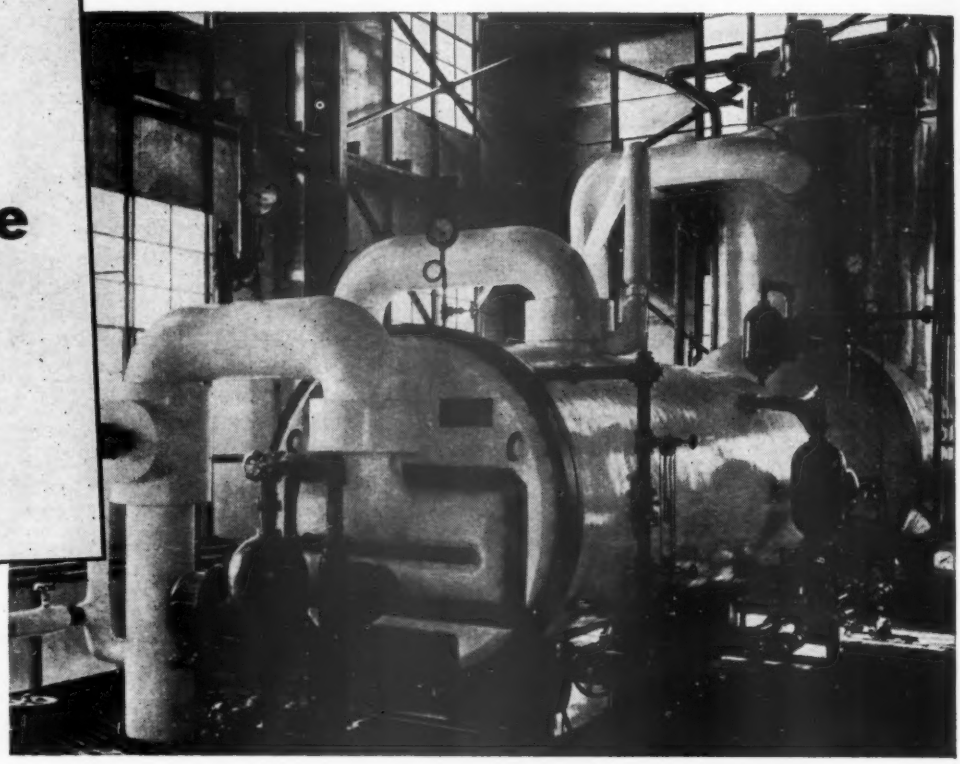


Transverse cross section of the Clark TRA Turbocharged 2-Cycle Gas-Engine-Driven Compressor.

Important!

if you have a moderate size boiler plant





Evaporators for eliminating the impurities from boiler feed make-up were originally developed for large power generating stations.

However, the results obtained with G-R Type R Horizontal and Type H Vertical Bentube Evaporators in industrial plants all over the country have proved that *moderate size plants* can also frequently profit by the many benefits of distilling the raw water supply.

This is a possibility well worth your investigation. Boiler feed purification by G-R Evaporators does not involve the use of chemicals nor require periodical water tests or manipulation by skilled operators. Moreover, it is the simplest method of eliminating raw water impurities.

Write for complete information.

THE GRISCOM-RUSSELL CO.
MASSILLON, OHIO

G-R Type R and Type H Evaporators are adaptations of the larger Type J-2 Bentube Evaporator—widely used by central power generating stations. They embody the exclusive scale-shedding G-R Bentube heating elements, and have many additional distinctive G-R features that assure ample capacity, pure dry vapor, long service, low maintenance expense and convenient attendance.

GR302

G-R HEAT TRANSFER APPARATUS **Bentube Evaporators**

It takes a Giant to catch a Giant

IT'S always exciting to watch a little guy challenge a big guy—and win. That's why Jack the Giant Killer has topped the list of popular children's stories for centuries. And that's why we think the oil business is the most thrilling business in the world. It's a contest between Men and a modern Colossus.

Not just any men. It takes men of tremendous initiative and daring—giants in their own right—to stalk the reluctant giant, Petroleum, drag him from his lair, civilize him, and put him to work.

Cities Service is well equipped with such men. Geologists who, at great personal hardship, track down the giant in his native haunts. Production men who risk all to bring him out alive. Refinery operations men, who domesticate and train him. Research men, who think of new ways to utilize his strength.

The mammoth muscles of petroleum have taken over some of mankind's hardest, most back-breaking jobs. We think a lot of credit is due the great-hearted Cities Service "Jacks" who've devoted their lives to finding, catching and domesticating this mightiest of modern "Giants."

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302B	309Cb	317	347	430
304	310	321	403	443
308	314	329	405	446
309	316	INCONEL * — NICHROME **		

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Gloweld electric welded stainless steel tubing is available in sizes ranging from ¼ inch to 5 inches O.D. inclusive; in standard weight pipe (schedule 40) sizes ⅛ inch to 2 inches — lightweight pipe (schedule 5 and 10) ⅛ inch to 4½ inches inclusive.

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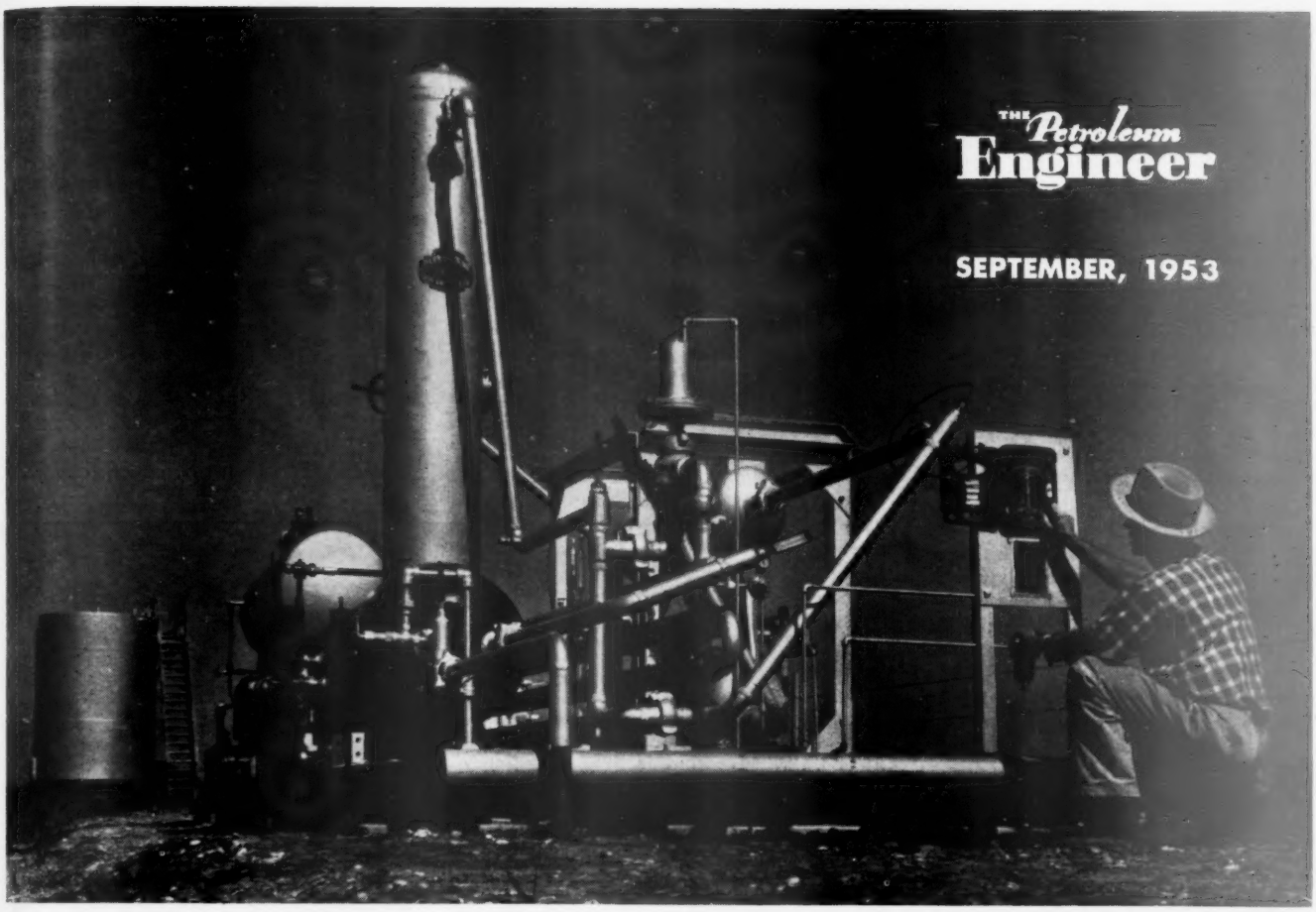

Low temperature separators aid in more efficient utilization of nation's oil reserves by removing liquid fractions from natural gas before it is turned into facilities of pipe line companies. Will use of this field separator unit be deemed "processing" by federal courts in determining whether production and gathering have been completed prior to sale of gas processed? That is the latest question in the long FPC controversy. The separator above is in Shell Oil Company's Iowa field near Lake Charles, Louisiana.

Federal Control Can Flow Through Gas Lines

U. S. Court of Appeals goes further than the FPC in holding that any firm selling gas to interstate pipe lines is subject to federal regulations

HAYDEN W. HEAD

THE Natural Gas Act of 1938 was passed as the result of a report made in 1936 to Congress by the Federal Trade Commission, which did not even remotely indicate that independent producers were a proper subject of federal regulation.[1] On the contrary, a clear distinction was drawn between independent producers and pipe line transmission companies, with the independent producer being described sympathetically as having no competitive market for his gas and being at the mercy of the pipe line companies. The term "independent producer" as used in the report applied to any producer which was not also a pipe line transmission company nor affiliated with such a company, and this meaning of the term has attached ever since in discussions of the Natural Gas Act. The report described the industry as being divided into three parts:[2]

> "So, broadly speaking, we have in natural gas a situation which no matter how fully and properly integrated will present at both ends problems which are either entirely of local concern, or which are of both local and general public concern, and in between a field of interstate transportation where only through the exercise of Federal jurisdiction can proper solution be obtained."

Following this report hearings began in 1936 before Congressional committees on various bills[3] dealing with the subject. The then solicitor of the Federal Power Commission, Dozier A. DeVane, testified during the hearings repeatedly that the rate paid to the producer and gatherer through "arm's length" sales was not covered by the Act and there was no disagreement with this by anyone throughout the hearings.[4] The term "arm's length" also has been used frequently since in discussing the Natural Gas Act, and as used, it is descriptive of any bona fide sale to a

EXCLUSIVE

purchaser with which the seller is not affiliated.

The importance Congress attached to the report of the Federal Trade Commission is not only apparent from its mention in the first sentence of Section 1 (a) of the Act[5] as finally passed but is further reflected in Section 1 (b) with its specific exemptions of "local distribution" and "production or gathering," which accord with the tripartite division of the industry established by the report and its recommendation that only the "in between" phase be federally regulated. It also accords with all testimony heard by Congress on this section of the bill. The following is Section 1 (b), the jurisdictional section of the Act:

> "The provisions of this chapter shall apply to the transportation of natural gas in interstate commerce, to the sale in interstate commerce of natural gas for resale for ultimate public consumption for domestic, commercial, industrial, or any other use, and to natural-gas companies engaged in such transportation or sale, *but shall not apply* to any other transportation or sale of natural gas or *to the local distribution* of natural gas or to the facilities used for such distribution *or to the production or gathering of natural gas.*" (Emphasis supplied).

Although the analogy is not mentioned in the Federal Trade Commission report, Congress no doubt recognized that it is no more logical that natural gas at its source be regulated than that coal or fuel oil be regulated merely because these fuels go, via franchised distribution systems, in the form of manufactured gas or electricity to ultimate consumers.

Commission Rulings

In 1940 the Federal Power Commission first considered the question of its jurisdiction over gas sales made by a producer and gatherer which was neither an interstate transmission company nor affiliated with such a company in the matter of Columbian Fuel Corporation.[6] The commission held that the sales in question were not subject to its jurisdiction and from that day until this, the Federal Power Commission has never once held in any case coming before it that it had jurisdiction over a producer or gatherer as a result of field sales alone. On the contrary, it has consistently held in eight subsequent cases[7] that it has no jurisdiction over "independent" producers and gatherers making "arm's length" sales of natural gas for resale in interstate commerce, due to the exemption of production and gathering.[8]

Immediately then the question comes —Why has there arisen any controversy if the Federal Power Commission has never held that it has jurisdiction over independent producers and gatherers of natural gas? The answer to the question has four basic components. The first is the commission itself. The second is the commission staff. The third is the group of "liberal" newspaper columnists, nationally syndicated, who systematically attack any and every phase of the oil and gas industry. The fourth is the unfortunate ability of our federal courts entire lack of perception and understanding of issues presented for decision.

Members of Commission

The commission itself is composed of five men appointed by the President and subject to confirmation by the Senate.[9] It was originally established in 1920 to regulate interstate sales of electrical power, and the regulation of "natural-gas companies," *i.e.*, companies subject to the jurisdiction of the commission under the Natural Gas Act, was simply added to the scope of its endeavors in 1938 when the Act was passed. Theoretically, its membership is representative of all sections of the United States to obfuscate their opinions on matters arising under the Natural Gas Act by language which frequently illustrates an and of both political parties. Terms of the members of the commission are for five years, but a turnover and replacement of members has occurred not only through expiration of their appointive terms but through resignations as well. At the time this is written the commission is composed of Chairman Kuykendall and Commissioners Smith, Draper, Doty, and Digby. Naturally, every official act of the commission since its creation represents the collective, yet individual, conclusion of a majority of the members serving at the time that particular action was taken.

Almost as important in commission action, and possibly more important in terms of long range ultimates to be achieved, is the commission staff, which is made up of a large number of semi-permanent federal employees who, for the most part, continue in their positions year after year without regard to changes in the identity of commission members. To a great extent, the commission's staff necessarily exercises a strong influence over the thinking of the commission members, particularly in matters in which the members may not be well versed. The effect of the staff can be much the same as that of never ending drops of water on even the hardest stone. It is not the size of the drops that count but their endless continuity.

To all of this must be added the effect of the newspaper columnists who have fanned a very small spark into a burning issue. Drew Pearson, Marquis Childs, Lowell Mellett, and Doris Fleeson, to name those who most consistently picture the independent producer of gas as a powerful ogre with the consumer at his mercy, devote a great deal of their allotted space to violent castigation of those members of the commission who have sought to preserve the exclusion of independent producers from the Act as intended by Congress. On the other hand, those members of the commission who have reached out for this unwarranted power of regulation are depicted by the columnists as saintly protectors of the consumer.

"Change of Mind"

It is interesting to note the "change of mind" of Commissioner Leland Olds during the period from 1947 to 1949. Olds was a "left-winger" whose writings appeared with some regularity in "The Daily Worker" for many years prior to his appointment by then Governor

The Author

Hayden W. Head is an attorney at law with offices in Austin and Corpus Christi, Texas, commuting between the two by Beechcraft Bonanza which he pilots himself, having spent four years in the Air Force during World War II.

A graduate of Austin College and the University of Texas, he opened law offices in Corpus in 1937 immediately upon graduation and in 1949 moved to Austin. Head's law practice has been primarily devoted to oil and gas law or its related phases. His interest in the FPC controversy began shortly after the Circuit Court's opinion in the Interstate case in 1946, and since that time he has followed and participated in the fight closely in an effort to avoid commission regulation of the independent producers he represents.

Head testified before the House Interstate and Foreign Commerce subcommittee in 1949, and before the Senate Interstate and Foreign Commerce subcommittee on the bills later combined and known as the Kerr-Harris bill, which passed Congress but was vetoed by former President Truman.

Hayden W. Head

He is at present vice chairman of the Committee on Mineral Law of the State Bar of Texas and also a member of the American Bar Association. Recently he, with a group of other men, purchased the Wichita Falls and Southern Railroad Company, and he is now president of the company.

Roosevelt to the New York Public Service Commission, which was later followed by his appointment by President Roosevelt to the Federal Power Commission.[10] A brief review of the chronology of Olds' change of mind is not only interesting but also serves as an appropriate illustration of the vice of the bureaucratic theory that ours should be a government of men and not of laws.

The Federal Power Commission on August 7, 1947, issued its Order No. 139, in which it ruled, among other similar statements to the same effect, that:

> "The Commission gives its assurance to independent producers and gatherers of natural gas that they can sell at arms' length and deliver such gas to interstate pipe lines and can enter into contracts for such sale without apprehension that in so doing they may become subject to assertions of jurisdiction by the Commission under the Natural Gas Act."

Commissioner Olds joined in the order and he, with all of the other then members of the commission, joined in writing a letter to Chairman Wolverton, chairman of the House Committee on Interstate and Foreign Commerce, recommending passage of the Priest Bill,[11] the sole purpose of which was to make it clear that independent producers and gatherers were not subject to the jurisdiction of the commission. In hearings in 1949 on the Kerr-Harris Bill,[12] which had the identical purpose of the Priest bill, however, Olds took a directly contrary position to that which he had previously taken. He was joined in this by Commissioner Buchanan, a disciple of Olds who had been appointed to the Commission not long before, and by Commissioner Draper, who was of the opinion that the Interstate case[13] controlled the question adequately and who, on that ground, had been the lone dissenter to Order 139 in 1947. So for a time a majority of the commission openly advocated extension of jurisdiction to the control of independent producers and gatherers.

When the Kerr-Harris bill was passed by Congress only to be vetoed by President Truman in 1950,[14] the commission rescinded Order 139,[15] but fortunately, no case involving the jurisdictional status of an independent producer or gatherer was decided during this period. More fortunately still, both Olds and Buchanan failed of confirmation by the Senate when their respective terms expired and are no longer on the commission.

Briefs Differ

The court decision that created the greatest controversy was the 1947 decision of the Supreme Court in Interstate Natural Gas Company vs. Federal Power Commission.[16] Interstate purchased gas from others in the Monroe field in Louisiana, commingled it with gas it had produced and gathered and then transported the commingled gas through its main line, from which it made resales. Interstate was admittedly a "natural gas company" as a result of its interstate transmission, but when the Federal Power Commission sought to regulate the price of gas produced by it for rate-base purposes, Interstate maintained that its field prices came within the production and gathering exemption of the Act and were not subject to commission regulation. In its brief filed in the Court of Appeals for the Fifth Circuit in that case,[17] the commission took the position that all field sales, whether made by independent producers or by natural-gas companies, were subject to commission regulation, but in its brief filed in the Supreme Court, the commission repeatedly and specifically emphasized its lack of jurisdiction over arm's length sales made by independent producers and gatherers. It is to be assumed that in doing so, the Commission itself had countermanded its staff's action after the damage had already been done by the Commission's brief in the Court of Appeals.

The Supreme Court in a unanimous opinion affirmed the holding of the Court of Appeals and held that Interstate's sales did not come within the production and gathering exemption of the Act. The language used was so broad that it was felt by many that the court inclined to the view that all producers and gatherers, independent or not, were subject to the commission's regulation. The court qualified the sweep of its language only to this extent:

> "Thus, where sales, though technically consummated in interstate commerce, are made during the course of production and gathering and are so closely connected with the local incidents of that process as to render rate regulation by the Federal Power Commission inconsistent or a substantial interference with the exercise by the state of its regulatory functions, the jurisdiction of the Federal Power Commission does not attach. But such conflict must be clearly shown. Exceptions to the primary grant of jurisdiction in the section are to be strictly construed. It is not sufficient to defeat the Commission's jurisdiction over sales for resale in interstate commerce to assert that in the exercise of the power of rate regulation in such cases, local interests may in some degree be affected."

However, on June 20, 1949, the Supreme Court handed down its opinion in the case of Federal Power Commission vs. Panhandle Eastern Pipe Line Company,[18] and there the clear indication seemed to be that the court did not regard field sales made by independent producers and gatherers as subject to the regulatory powers of the commission. The actual holding of the court was that the commission had no authority to prevent the transfer by Panhandle Eastern, an admitted "natural-gas company" subject to the commission's jurisdiction, of dedicated producing gas leases owned by it to Hugoton Production Company, a corporation that had been organized by Panhandle Eastern and all of the stock in which had been distributed to Panhandle Eastern stockholders in the form of a stock dividend. The court used this language:

> "The legislative history of this Act is replete with evidence of the care taken by Congress to keep the power over the production and gathering of gas within the states. This probably occurred because the state legislatures, in the interests of conservation, had delegated broad and elaborate power to their regulatory bodies over all aspects of producing gas. The Natural Gas Act was designed to supplement state power and to produce a harmonious and comprehensive regulation of the industry. Neither state nor federal regulatory body was to encroach upon the jurisdiction of the other. Congress enacted this Act after full consideration of the problems of production and distribution. It considered the state interests as well as the national interest. It had both producers and consumers in mind. Legislative adjustments were made to reconcile the conflicting views."

A review of this vital question of federal control of gas sales in the field reveals glimpses of the difficulty of presenting highly technical operational and economic situations to a federal commission and to federal courts.

In a long footnote, the court referred specifically to the controversy over regulation of field sales by independent producers and gatherers, apparently approving the view of Commissioners Smith and Wimberly that the commission had no jurisdiction over such sales. It is believed that in the Panhandle Eastern case the Supreme Court deliberately made an effort to restrict the language used in its opinion in the Interstate case.

Phillips Case

This brings us to the proceeding instituted by the commission in 1948, while Olds and Buchanan were among its members, to determine whether it had jurisdiction over Phillips Petroleum Company solely because of "arm's length" sales made by Phillips to various interstate pipeline companies.[19] The Commission ordered an investigation of Phillips on October 28, 1948, to determine whether it is a natural gas company and on February 9, 1950, ordered

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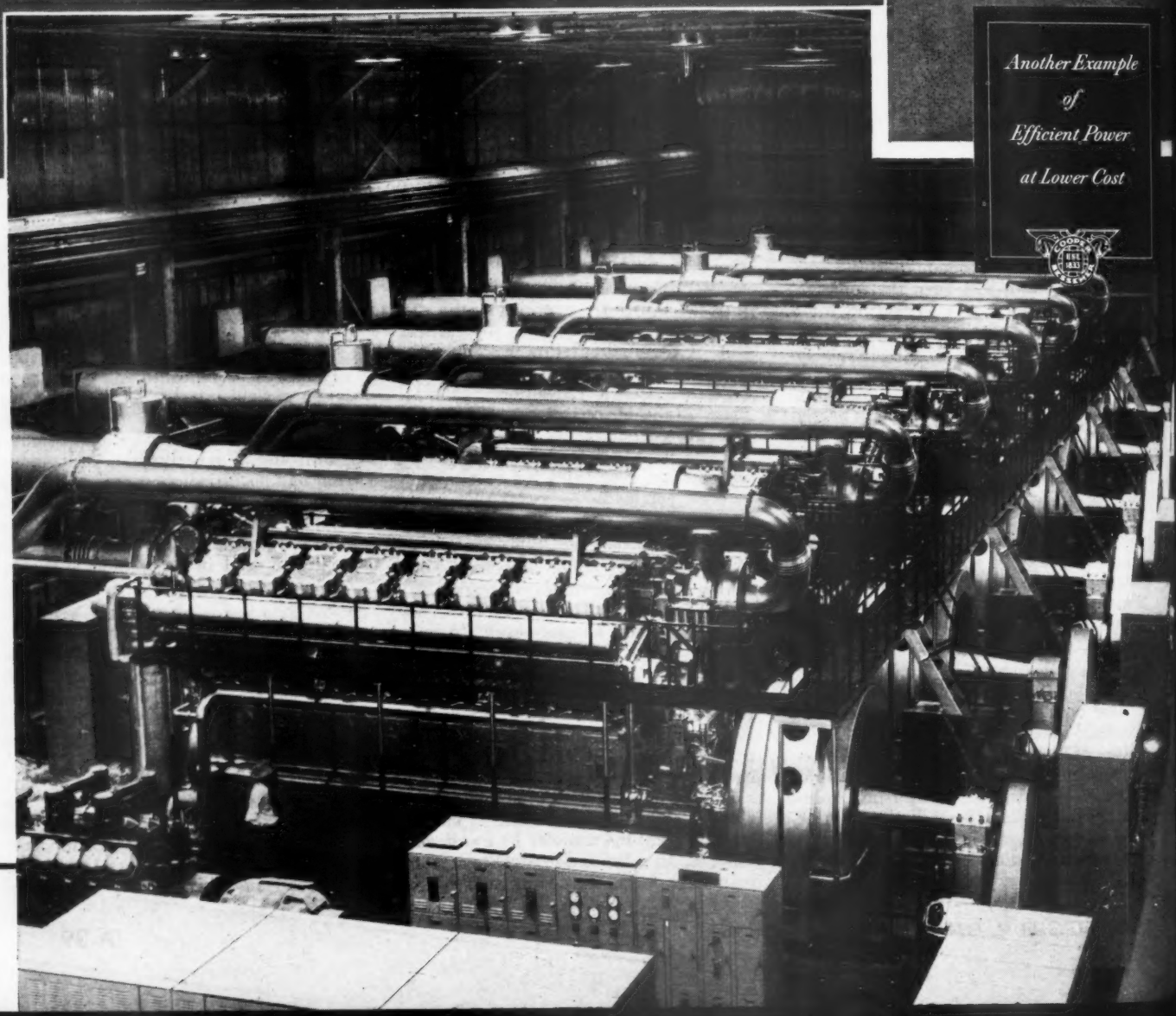

Another Example of Efficient Power at Lower Cost

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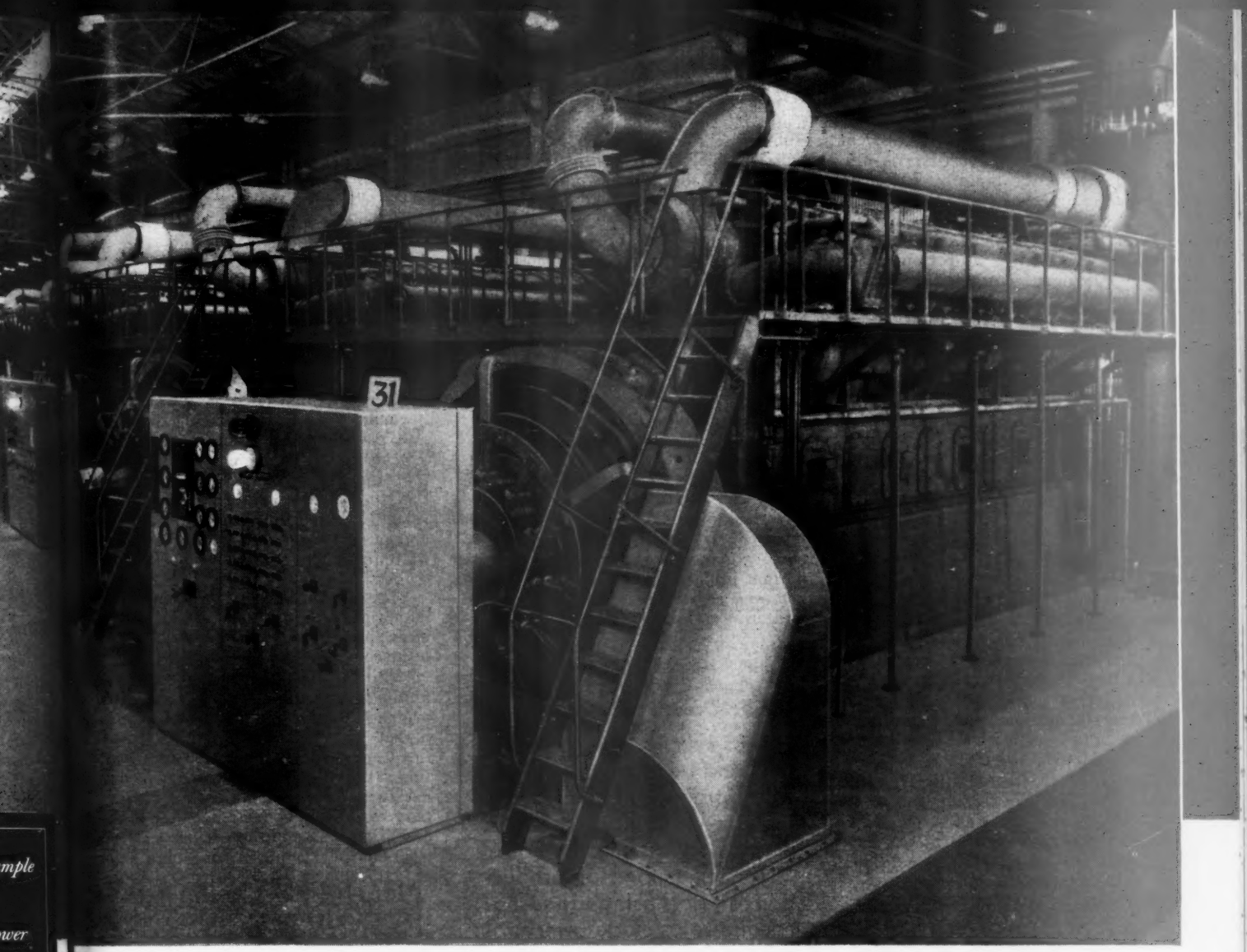

Left, opposite: Craneway view of 6 of the 9 Cooper-Bessemer LSV-16's driving General Electric A.C. generators for over-all plant service. Both these and the O.C. potline units, 42 Cooper-Bessemers in all, are completely protected from any type of operating damage by automatic shutdown devices with suitable anticipatory alarms.

Above: Line-up of 16 of the 33 Cooper-Bessemer LSV-16, 3,700 hp gas engines, driving General Electric O.C. generators, for powering pot line No. 1 in Reynolds' new Corpus Christi aluminum reduction plant.

RECORD-BREAKING is right! There's no other electric generating facility in the United States that can match the low cost power of the Reynolds Metals Company's huge new aluminum reduction plant at San Patricio near Corpus Christi, Texas.

Shown here are some of the 42 big Cooper-Bessemer LSV gas engines that help make this remarkable economy possible. These are 3,700 hp, spark-ignited, 4-cycle, 16 cylinder *supercharged* engines – Cooper-Bessemers with a thermal efficiency that consumes only 10 cubic feet of gas per kilowatt hour. To give you a rough idea, these Cooper-Bessemers at Reynolds Metals *save* enough *daily* to serve a city of 25,000 population.

Add to this efficiency the fact that these Cooper-Bessemers are quiet, smooth-running engines, designed for continuous operation. You'll find that it means, as usual, exceptional economy and satisfaction *plus*.

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hearings to be held. Following President Truman's veto of the Kerr-Harris bill, April 15, 1950, the State of Wisconsin and Public Service Commission of Wisconsin, City of Detroit, Michigan, City of Kansas City, Missouri, City of Milwaukee, Wisconsin, and County of Wayne, Michigan, intervened in support of jurisdiction by the commission over Phillips' sales. The States of Arkansas, Louisiana, Mississippi, New Mexico, Oklahoma, and Texas intervened in opposition to commission jurisdiction.

Phillips then filed motion to limit issues to the queston of whether Phillips was an independent producer and gatherer within the meaning of the Commission's Order No. 139 and a week later the Commission rescinded Order No. 139 by its Order No. 154. The hearing commenced at Bartlesville, Oklahoma, on April 3, 1951 and filled more than 6000 pages of testimony, with almost two hundred exhibits. After two days of oral argument before the commission itself in Washington, it held[20] on August 16, 1951 that Phillips was not subject to its jurisdiction. Chairman Wallgren and Commissioners Smith and Wimberly joined in the majority opinion, which was essentially predicated on two grounds, the first being:

> "We find that its [Phillips] operations, so far as relevant, consist of production and gathering, or incidents of or activities related to these functions thus requiring their inclusion within the Act's exemption."

The second ground of the majority opinion is:

> "In varying degrees, the evidence clearly shows that our regulation of sales made in the process of production and gathering would, by its very nature, be inconsistent or constitute a substantial interference with such regulation of producers and gatherers by Oklahoma, Texas, and New Mexico. To cite one example, there is a direct relation between price and conservation, an important concern in the regulation of each of the States."

Commissioner Draper wrote a separate concurring opinion based on the second ground alone. In so doing he maintained a position of consistency in his interpretation of the Interstate case, for he points out that the evidence in the Phillips case established a conflict with state regulatory authority which distinguished it from the Interstate case. Commissioner Buchanan dissented and in a long opinion expressed his conviction that Phillips' sales made it subject to the jurisdiction of the commission, even though it was not otherwise a natural gas company.

Court Reverses Commission

On May 22, 1953, the Court of Appeals for the District of Columbia Circuit handed down its opinion,[21] with one judge dissenting, reversing the Federal Power Commission and holding Phillips to be a "natural-gas company" subject to rate regulation by the commission solely by reason of its sales of natural gas to interstate pipe line companies. This shook the industry to a very considerable degree, for so rare is a negative ruling of jurisdiction by any federal bureau that it had almost been taken for granted that the court would approve the commission in holding, as it had for the eleven years preceding, that it had no jurisdiction over producers and gatherers who were not natural-gas companies by virtue of interstate transmission or affiliation with interstate transmission companies.

It is to be regretted exceedingly that the opinion of the majority of the court in the Phillips case, regardless of the conclusion reached, evidences a thorough lack of understanding of the issue involved. It reflects no more than a cursory glance at the tremendously important problem before the court, being not even as well reasoned nor as well written as Commissioner Buchanan's dissent to the same end in the proceeding before the commission. It does not even discuss the historic issue of whether there should be a distinction between "independent producers" making sales at "arm's length," mentioned by the Supreme Court in the Panhandle Eastern case as recently as 1949.

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U. S. Court of Appeals:

Phillips sells its gas "after the time and beyond the place at which production and gathering are complete and after processing has intervened.

"The exemption of production or gathering does not exempt sales made after production and gathering have been completed.

. . . "Therefore Phillips is a 'natural gas company' within the meaning of the Natural Gas Act and the Commission (FPC) should fix the rates at which these sales are made."

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Meaning of "Wholesale"

The Circuit Court regarded the sales by Phillips as being identical with the "wholesale" sales made by Interstate Natural Gas Company, discussed above, and Colorado Interstate Gas Company, discussed below, both of which were admittedly "natural-gas companies," subject to the commission's jurisdiction by reason of their production *and* interstate pipeline transportation of gas, while this was not true of Phillips, which only produced, gathered and "processed." Yet it had been made quite clear, without disagreement, in the 1937 Congressional hearings that the "wholesale" sales to be subject to regulation were only those of a transmission company or a producing company which was also a transmission company.[22]

The Court's Decision

The Circuit Court's majority begins its opinion (the second paragraph) by assuming the answer to the question presented in saying perfunctorily that Phillips sells its gas "after the time and beyond the place at which production and gathering are complete and after *processing* has intervened." It then holds that the commission's finding of fact that the sales were made incident and related to the function of production and gathering cannot stand. It concludes its opinion:

> "The exemption of production or gathering does not exempt sales made after production and gathering have been completed.
>
> "Phillips urges that the Commission's findings are supported by substantial evidence and should therefore be sustained. But the validity or invalidity of the Commission's conclusion that Phillips is not a 'natural-gas company' does not turn upon the evaluation of testimony or upon any facts peculiar to this case. It turns upon the generic question whether the exemption of "production or gathering' in § 1 (b) of the Natural Gas Act covers interstate sales of gas by the corporation that produced and gathered it. We think the Act and the decisions of the Supreme Court permit only one answer. We think the Commission has applied an erroneous rule of law. Phillips' sales to the pipe line companies are not within either the statutory phrase 'the production or gathering of natural gas' or the Supreme Court's paraphrase 'made during the course of production and gathering.' Therefore Phillips is a 'natural-gas company' within the meaning of the Natural Gas Act and the Commission should fix the rates at which these sales are made."

The quoted language is sweeping and is difficult to reconcile with the Circuit Court's recognition, midway in the majority opinion, of the validity of the rule laid down by the Supreme Court in the Cities Service-Peerless case,[23] which is discussed below. The majority says:

> "That case upholds a state's power, in aid of conservation, to fix minimum prices for natural gas sold at the wellhead for interstate movement. Such sales are obviously made during the 'production and gathering' which Congress reserved to state control, and it 'is now well settled that a state may regulate matters of local concern over which federal authority has not been exercised, even though the regulation has some impact on interstate commerce."

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This gives rise to a great many questions. Does the court use the term "wellhead sales" synonymously with "field sales," as did the Supreme Court in the Cities Service-Peerless case, discussed below, and if not, where is the dividing line? If it does not use the terms synonymously, does the court realize that all gas delivered to interstate transmission companies has been first produced, gathered, and in practically all instances, processed in some manner (by field separators, by plant processing or both) prior to its sale? Do these facts of themselves answer in all cases the "generic question" upon which the majority of the Circuit Court decided that evidence as to the meaning of the terms "production" and "gathering" had no bearing? Is the term "processing" also generic, so that the court needs no evidence to determine its meaning? All of these questions remain unanswered and by the same token, so does the fate of the great majority of independent producers who make sales to interstate gas transmission companies.

Blow at Conservation

In any event, the majority of the court strikes a serious and damaging blow at state conservation efforts. If the producer who processes his gas through a "processing plant" becomes subject to federal regulation and the producer who makes "wellhead" sales does not, it seems quite likely that the "processing plant" and its recovery of liquid hydrocarbons, otherwise wasted, may well be on its way to obsolescence. Yet this is directly counter to basic conservation efforts of the states and is only one example of the conflict thrust upon state regulatory authorities by the court. In its failure to consider the federal-state conflict thus arising, it is most evident that the majority of the Circuit Court failed to penetrate even the veneer of this highly complex question and that it wilfully disregarded the Supreme Court's ruling in the Interstate case that where there is "a substantial interference with the exercise by the State of its regulatory functions, the jurisdiction of the Federal Power Commission does not attach." The Circuit Court's majority does not mention the testimony of conservation officials from the states of Texas, Oklahoma and New Mexico that federal regulation would constitute a substantial interference and conflict with their regulation of Phillips' operations. A footnote to the majority opinion simply states tersely, in effect, that it considers any contention of federal-state conflict unsupportable *as a matter of law.*

The dissenting opinion, after reviewing the evidence, the commission's findings, the Interstate case and the Panhandle Eastern case, among others, concludes:

"To me, it seems inescapable under the statute, under the decisions, and in the name of plain economic common sense, that sales by a gatherer are a part of gathering so long as they are made before the gas enters the transmission lines proper. It is the function of the Commission to determine whether, in fact, the gas is sold before or after that point. A finding was made by the Commission in this case that the gas was sold while it was still in the gathering lines and that finding seems unassailable either in fact or under the law as I interpret it."

But the worst was yet to come. On July 20, 1953, the Court of Appeals for the Eighth Circuit delivered[24] what could easily prove to be the knock-out blow to the independent producer when it held that the Federal Power Commission could completely disregard the minimum price order of the Kansas Corporation Commission. Although the company there before the court was Northern Natural Gas Company, an admitted "natural-gas company" subject to the jurisdiction of the commission, the court cited the decision of the Court of Appeals for the District of Columbia in the Phillips case at great length with approval and said that the sales which Phillips made "were analogous to the sales that Northern makes in this case." That statement is grossly inaccurate and is a perfect illustration of the previously mentioned judicial obfuscation which has brought the independent producer to the brink of disaster. Compare the statement of Phillips' gas operations taken from the second paragraph of the majority opinion in the Phillips case:

"Phillips is a very large operator in the petroleum industry and a very large producer, gatherer, and processor of natural gas from wells in Texas, Oklahoma, and New Mexico. Phillips owns and operates nine gathering systems and ten processing plants. Through progressively larger pipelines it gathers gas that it produces from its own wells, and other gas that it buys, at common points in or near its plants. At these plants it processes the gas to make it salable or to recover extractable products or both. Phillips then moves the gas here involved through short lines to points where Phillips sells it to Michigan-Wisconsin Pipe Line Company, Panhandle Eastern Pipe Line Company, Independent Natural Gas Company, El Paso Natural Gas Company, or Cities Service Gas Company, for interstate transportation and resale."

Below is the statement of Northern Natural's gas operations taken from the second paragraph of the majority opinion in the Northern Natural case:

"Northern, as of the close of 1950, was engaged in operations in seven midwestern states, owning and operating an integrated natural gas pipe line system, producing, purchasing, transporting and selling natural gas at wholesale to 27 non-susbsidiary utility companies, which in turn served 136 cities and towns, and to its then wholly owned subsidiary (since absorbed by it), Peoples Natural Gas Company, which served 92 cities and towns. In adition, it was serving 16 large volume direct industrial customers in 19 locations, approximately 58 small volume drilling, pumping and irrigation customers, and approximately 1600 domestic customers."

No analogy can be drawn between these two wholly different sets of facts even by the wildest stretch of the imagination. One is compelled to the conclusion that the Circuit Court in the Northern Natural case was neither concerned with the facts of the Phillips case nor the effect of its own approval of that decision, but only with phrasing legal abstrusions.

State Price Upheld

The background of the particular aspect of the subject controversy which was before the court in the Northern Natural case is of relatively recent origin. On December 11, 1950, the Supreme Court handed down its opinion in the case of Cities Service Gas Company vs. Peerless Oil and Gas Company.[25] The question before the court was the validity of an order of the Oklahoma Corporation Commission which fixed the minimum price to be paid at the wellhead for gas produced in the Guymon-Hugoton field in Oklahoma. The Court held the state order valid even as to gas which moved in interstate commerce, saying that the producing state could, in conservation of its natural resources, establish a minimum wellhead price although it had an impact on interstate commerce. The Court recognized that:

> "... the wellhead price of gas is but a fraction of the price paid by domestic consumers at the burner tip, so that the field price as herein set may have little or no effect on the domestic delivered price."

The court did state that the question of whether the Natural Gas Act authorizes the Federal Power Commission to set field prices on sales by "independent producers" or leaves that function to the states was not before it for decision, but it logically followed that if conservation regulation by minimum field price came within the established sphere of state regulatory jurisdiction, as the court held in the Peerless case, then Congress did not intrude into this sphere by the passage of the Natural Gas Act, which is the rule laid down in the Panhandle Eastern case.

Following the principle in the Cities Service-Peerless case, the Supreme Court of Kansas[26] held valid an order of the Kansas Corporation Commission fixing a minimum price of 8 cents per 1000 cu ft for gas at the wellhead in the Hugoton field in that state. The Kansas court found state regulation to be a valid measure in aid of conservation, saying that the Natural Gas Act takes cognizance of the powers of the state "to conserve natural gas and to prevent waste

in its production, gathering, distribution or sale." Northern Natural Gas Company made application (among other things) to the Federal Power Commission to be allowed to include, for rate base purposes, the gas which it produced from the Hugoton field at the value required by the order of the Kansas Corporation Commission to be "attributed" to gas "at the wellhead."

State Price Destroyed

The Federal Power Commission held that it was not required to allow Northern Natural the value required by the order of the state commission, but that only the actual cost (5 cents per 1000 cu ft) of the gas produced by Northern Natural should be allowed.[27] Commissioner Wimberly dissented on the ground that the action of the majority (Smith, Buchanan, Doty, and Draper) nullified Kansas' conservation program and that the Federal Power Commission had no authority to interfere in "this most essential task of conservation of natural gas."

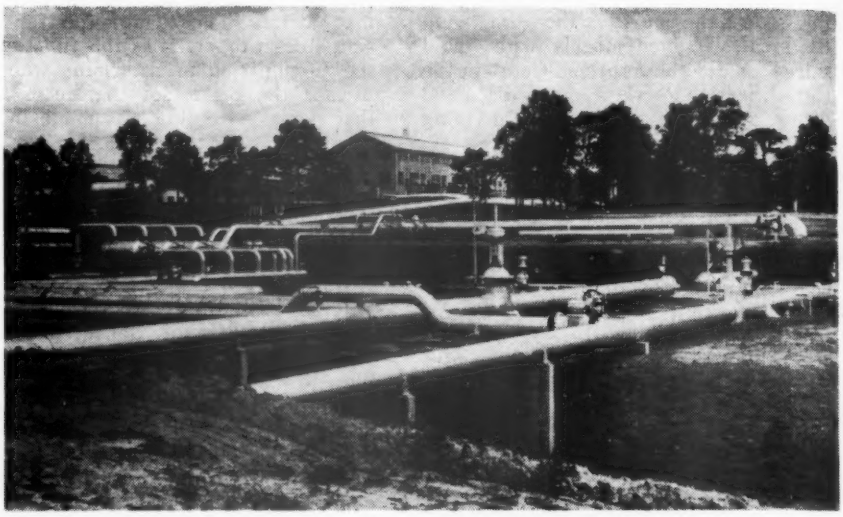
The Court of Appeals, in affirming this ruling of the commission, says that the holding of the Supreme Court in the Cities Service-Peerless case was "narrowly applicable to the particular situation [of Peerless] before the [Supreme] Court." However, under the test laid down in the Phillips case, which is approved by the court in the Northern Natural case, Peerless would quite possibly be held to be a "natural-gas company" simply by virtue of its sales to Cities Service, with the result that the rate allowed it would not be the minimum wellhead price fixed by the Oklahoma Corporation Commission and held valid by the Supreme Court, but instead would be the actual cost to Peerless of producing its gas in accordance with the formula applied to Northern Natural by the Federal Power Commission. Thus the two Circuit Courts almost simultaneously close the circle of exclusive federal regulation around the independent producer.

A separate concurring opinion was written by one of the three Circuit judges in the Northern Natural case in which the view was expressed that the Federal Power Commission could not completely ignore the Kansas attribution order as a proper state regulation in the field of gas production, but "for the sake of unanimity in our disposition" concurs in the holding of the majority on the ground that all of the rates fixed by the commission at which Northern Natural was permitted to *sell* exceeded 8 cents per 1000 cu ft. This is even more specious than that of the majority of the court but since it does dissent to the reasoning, although not the holding, of the majority, it may serve some purpose.

Size Judged?

There is little doubt but that the size of Phillips' operations had much to do with its selection by the Federal Power Commission in 1948 as the most desirable target of all independent producers and gatherers. It is by far the largest marketer of gas to interstate transmission lines in the United States. Its total sales of natural gas during 1949 amounted to almost one-half trillion cubic feet and at the end of that year it owned and controlled by contract more than fifteen trillion cubic feet of proved gas reserves. Phillips qualifies as an independent producer and gatherer, however, making sales at arm's length under the standards set by the Federal Trade Commission in its report, by the Federal Power Commission in its representations to Congress upon which the Natural Gas Act was based and by the consistent rulings of the commission over a period of eleven years. Phillips' cardinal sin, therefore, would appear to be bigness, which no doubt impressed the Court of Appeals in its determination that Phillips is subject to the jurisdiction of the commission as a "natural-gas company" under the Act. At the same time, bigness, as such, is not a jurisdictional criterion laid down anywhere in the Act, with the result that the standards devised by the court to extend jurisdictional coverage to Phillips are sufficiently fuzzy to permit some similar court hereafter to hold a one well producer, whose gas is processed through someone's plant prior to its sale to an interstate pipe line, to be subject to commission regulation as a "natural-gas company," a public utility.

Our concern is not for Phillips, whose operations are so extensive and diverse that its gross revenue from sales of natural gas, large as they are, account for only 5 per cent of its total gross revenues. No doubt Phillips could survive the burden of federal regulation of its gas sales, for it is also an integrated oil company and manufacturer of chemicals and carbon black, among other things, all of which go to make its overall operations profitable. Unfortunately, this is not true of very many of the thousands of independent producers who sell their gas to interstate pipe line companies. On the contrary, the average independent producer leads a rather precarious financial existence, with a slight downward change of price for his product sometimes resulting in foreclosure. And why is his financial condition usually precarious? It is because, as a rule, he spends all of the money he can get his hands on in drilling wildcat wells over the face of the earth trying to find oil and gas, with the odds being that at least eight out of every nine wildcat holes he drills will be plugged and abandoned, frequently at fantastic cost. Yet by sheer force of numbers and the money they spend looking for oil and gas, indpendent producers every year find most of the new reserves upon which this country's continued domestic production of gas and oil depends.



COMPRESSOR STATION on a pipe line system operating in interstate transmission of natural gas.

"Fair Rate" of Return

Reasons for the independent producer's fear of regulation under the Natural Gas Act are well founded. In the first place, the sales price of his gas would be fixed at an amount limited to a "fair rate" of return to him on his investment in the property subject to the commission's jurisdiction, less accrued depletion and depreciation, plus a working capital allowance. The "fair rate" of return for quite some time was set at 6½ per cent, but in the Northern Natural case this was reduced to 5½ per cent, which led the court to remand that one feature of the case to the commission for its redetermination on the ground that the evidence heard by the commission there did not support the commission's finding of 5½ per cent as a "fair rate," although it would have supported the findings of 6 per cent made by the examiner presiding at the hearing or of the 5¾ per cent, which one staff witness testified would be adequate.

What does it matter to the independent producer whether it be 5½ per cent,

6 per cent or 6½ per cent so long as his business by its very nature cannot be continued under any formula or concept of utility regulation? In most instances, the original investment cost of his producing lease or leases has been practically nothing. His primary investment has gone into dry holes on other leases long since abandoned, and which the commission's formula does not take into account. His gamble on the dry holes can and will be undertaken only if he can look forward to an unrestricted return on a producing property which, through luck and the grace of God, he may some day find. The theory of a percentage return on a rate base would offer little incentive to an independent producer to drill the dry holes necessary to discover a producing property when the property finally discovered would be put in the rate base at $4244.24, even though it had an actual value after discovery and development of more than three million dollars, simply because $4244.24 was his original cost of that property before his discovery of production. These are the precise figures and the formula used by the commission and upheld by the Supreme Court in the Colorado Interstate case,[28] where some of the proved leases there involved were put in the rate base at 10 cents per acre and others at zero. This is also one of the two cases upon which the Circuit Court relied most strongly in holding Phillips' sales subject to commission regulation.

Why FPC Control Would Cut Natural Gas Supply

1. An independent producer must make enough on producing wells to pay for dry holes or go broke. The "fair rate" of return fixed by the FPC would be based only on the producing property subject to commission jurisdiction.
2. It would be virtually impossible for the small producer to comply with accounting and reporting regulations designed for operations of interstate transmission companies whose lines extend throughout the United States.
3. It would be expensive and even dangerous at times for a producer to be forced to follow the regulations requiring permission of the FPC before all or any portion of the company's facilities, subject to the commission's jurisdiction, can be abandoned.
4. The independent producer who must sell to interstate markets at a fixed low price cannot be expected to conserve a product which has no value of importance to its owner.
5. State conservation laws wolud be more difficult to enforce and natural gas would be wasted if independent producers were placed under Federal Power Commission regulations.

Where Does Rate Fixing Stop?

But let us assume that the independent producer begins with a rate base greater than zero. As he receives income from his producing lease, his rate base dimishes and the road to zero allowance is inevitable. The income taken into account by the commission's formula in computing his diminishing investment is not only that received from the gas sold but from its liquid fractions extracted prior to sale.[29] If the liquid products of gas extracted prior to its sale are taken into account in establishing the return, as they are, then does it not also follow that, given the opportunity, the commission may take into account the value of oil produced with gas prior to its sale? Commission representatives have said in the past that it does not do this, never has and will not. But until May of this year, the commission had never had an independent producer judicially determined to be subject to its regulation, and it is considered unlikely that oil will receive different treatment from natural gasoline if and when independent producers of gas and oil should become subject to its jurisdiction as a matter of course. Until now there has been relatively little temptation to consider oil, for the interstate pipe line companies that heretofore have been the sole subject of commission regulation actually produce little gas and less oil. For instance, the evidence in the Northern Natural proceeding discussed above showed that it produced only 18.68 per cent, and purchased from other producers in Texas, Oklahoma and Kansas 81.32 per cent, of the total gas it sold to its interstate markets.

Another requirement of the Natural Gas Act that would be ill-suited to the survival of the independent producer is compliance with the accounting and report orders of the commission under Sections 6 (b), 8 (a), and 10 (a) of the Act. The Supreme Court holds that the cost of compliance is immaterial so long as "The evidence does not show that the expense . . . will lay so heavy a burden upon the companies as to overpass the bounds of reason."[30] It is probable that the great majority of independent producers would crack even before the bounds of reason were overpassed in complying with accounting and reporting regulations designed for the operations of the interstate transmission companies whose lines extend for thousands of miles throughout the continental limits of the United States. In that connection, it is interesting to note that in 1952, only 151 companies were classified as "natural-gas companies," filing the annual reports required under the Act, while at the same time there were almost 4000 independent producers and gatherers selling gas to these interstate transmission companies. The commission's brief in the Circuit Court in the Phillips case, filed in support of the commission's ruling that it had no jurisdiction, makes this comment in a footnote on the contention there made that it should undertake to regulate the "countless producers and gatherers, large and small," who sell to interstate transmission companies:

> "The relatively appalling proportions of the task of administration under such federal regulation, dwarfing the Commission's Staff and appropriations, provides still further evidence that the Commission has properly assessed the legislative intent of Section 1 (b). For it would thus appear that from the beginning Congress has never intended that the Commission undertake such a task."[31]

It is also thought that as a matter of economics the independent producer, if held to be a "natural gas company," would find compliance almost impossible with Section 7 of the Natural Gas Act, which not only allows the commission to direct a "natural-gas company" to extend its transportation facilities to furnish better public service but which also requires that "No natural-gas company shall abandon all or any portion of its facilities subject to the jurisdiction of the commission, or any service rendered by means of such facilities, without the permission of the commission first had and obtained . . ." These are mandatory requirements of the Act and their incongruity if applied to the independent producer, furnishes additional proof that Congress had no intention of bringing him within its regulation.

But for the moment let us turn from the problems of the independent producer to the regulatory problems forced upon state conservation authorities by the combination of the holdings of the two Circuit Courts in the Phillips and Northern Natural cases. Briefly, at least these things can be said in that regard:

(1) The independent producer or gatherer will be anything but cooperative in "plant processing" of his gas prior to its sale to an interstate pipe line company if he is subjected to Federal Power Commission regulation under the apparent rule laid down in the Phillips case. Plant processing has been not only encouraged but, in some instances, forced by state conservation officials to recover liquid products of gas which would be otherwise wasted.

(2) As price is the most important

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single factor in conservation, denial of the competitive fair market price to the independent producer who sells to interstate markets will unavoidably create physical waste underground through failure of recovery of gas and its associated hydrocarbons from the formation. Expenditures for equipment necessary to the complete production of marginal properties cannot and will not be made by the independent producer if his income is to be limited to a fractional rate of return on a fictitious rate base. By its refusal to recognize the Kansas minimum price order and its simultaneous approval of the holding in the Phillips case, the Circuit Court in the Northern Natural case effectively destroys price as a tool of conservation.

(3) For the same reason, the problems of state authorities in preventing physical waste of gas above ground will be multiplied many times, for the past has demonstrated the difficulty of enforcing conservation of a product which has no value to its owner

(4) Economic waste of this highly desirable and irreplaceable fuel, recognized by the Supreme Court in the Cities Service-Peerless case, will occur as a result of the rules laid down by the two Circuit Courts.

(5) If the Federal Power Commission should some day determine that it should fix the rate of production of gas from leases "dedicated" to interstate markets in order to protect the consumer, will this override the power of state officials to regulate production from those same leases to effect conservation? After all, it was only fifteen years ago that the Natural Gas Act was passed in an atmosphere of complete agreement that the independent producer and gatherer was not subject to its provisions, but two federal courts have now said the contrary. Is it not possible that by 1968 a federal court may say that the fact that Congress passed the Natural Gas Act at all evidenced its intent in 1938 that the entire production and gathering exemption of the Act must be given no effect as contrary to the "paramount right" of the consumer? In so holding, the court would need to disregard the legislative history of the Act to no greater degree than did the court in the Phillips case, although such a holding might require additional deviation from present rules of statutory construction.

The Future

However, the decisions of the two Circuit Courts are not final and it is entirely possible that the Supreme Court will agree to hear both the Phillips and Northern Natural cases in view of the importance of the questions there involved if for no other reason. Fortunately, there is no indication that the present members of the Federal Power Commission believe the commission's ruling of no jurisdiction in the Phillips case to be incorrect and it is hoped that the commission will maintain its position before the Supreme Court with some vigor, which certainly would not have been true in 1948. Further, the opinions of at least some members of the Supreme Court reflect a better understanding of the issues involved than do the opinions of the majority in both the Circuit Courts and if the Supreme Court does consent to hear the cases, it may, as it should take into consideration:

The Supreme Court's previous recognition in the Panhandle Eastern case that "Neither state nor federal regulatory body was to encroach on the jurisdiction of the other" and in the Cities Service case that a state's minimum price order was a valid exercise of its conservation power;

The hard, cold economic facts of the independent producer's business of exploring for, producing and selling natural gas;

The unavoidable conflict that will arise between federal utility regulation and state conservation regulation, as reflected by the testimony of conservation officials of three producing states and by the opinion of the commission itself in the Phillips case;

The undeniable fact that price is the most important incentive to both conservation and supply, since low field prices not only encourage waste but discourage exploration for new reserves;

The detriment to the consumer if federal regulation is allowed to stifle the independent producer who finds the gas supplied to the "natural-gas company" for transmission to the consumer, whose primary concern should be the continued supply of this exhaustible resource;[32]

The report of the Federal Trade Commission and the legislative history of the Act prior to and at the time of its passage when there was complete agreement that it did not apply to independent producers and gatherers and that the "wholesale" rate of gas subject to regulation was that of the producing company which was also a transmission company.

The Phillips and Northern Natural cases provide a highly desirable opportunity to the Supreme Court to free the independent producer from the chaotic state of uncertainty in which he has lived for the past seven years and at the same time, to commend a federal bureau that has ruled that it should not extend its jurisdiction into a field of regulation not contemplated by the power that created it. Whether the Supreme Court will do so or whether it will choose to hurl the producing segment of the industry into final chaos remains to be seen, but if it should elect to follow the latter course, it may be sure that the consumer, as well as the producer, will be some day afflicted with the injustice done, for federal control of the producer and gatherer can mean only less gas at higher prices. Under federal regulation of the producer and gatherer, the gas pipe line, required to make contracts which impose regulation on the seller, will have difficulty in getting gas at all, but in any case would always have to pay more than the intrastate customer who could be served without the potential penalty of regulation. In the long run, the consumer as well as the producer will profit from the absence of federal regulation and both will suffer from its imposition.

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3. The most important were H. R. 11662, 74th Cong. 2d Sess. (1936), the provisions of which were substantially those of H. R. 4008, 75th Cong., 1st Sess. (1937), which later became H. R. 6586 and was passed as the Natural Gas Act of 1938.
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5. Ch. 556, 52 Stat. 821, amended Ch. 49, 56 Stat. 83, amended Ch. 333, 61 Stat. 459; 15 U. S. C. A. Sec. 717.
6. 2 FPC 200 (1940).
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8. For extensive discussions of the subject, see 14 Geo. Wash. Law Rev., 30 (1945); 59 Yale L. J. 1468 (1950); 30 Tex. L. Rev. 20 (1951); 52 Cal. L. Rev. 135 (1952).
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12. H. R. 1758 and S. 1498, 81st Cong., 1st Sess. (1949) and hearings thereon.
13. Interstate Natural Gas Co. v. Federal Power Commission, 331 U. S. 682; 67 S. Ct. 1482 (1947).
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25. 340 U. S. 179; 71 S. Ct. 215 (1950).
26. Kansas-Nebraska N. Gas Co. v. State Corp. Com'n. 222 P. (2) 704 (1950).
27. Opinion No. 228 of the Federal Power Commission. In the Matter of Northern Natural Gas Company, Docket Nos. 6-1382, 6-1533, 6-1607.
28. Colorado Interstate Gas Co. v. Federal Power Commission, 324 U. S. 581; 65 S. Ct. 829 (1945).
29. Cities Service Gas Co. v. Federal Power Commission, 155 F (2) 694, Cert. den. 329 U. S. 773, 67 S. Ct. 191 (1946).
30. Federal Power Commission v. East Ohio Gas Co., 3380 U. S. 464, 70 S. Ct. (1950) quoting American Telephone & Telegraph Co. v. United States, 299 U. S. 232, 57 S. Ct. 170.
31. Brief for Respondent Federal Power Commission in the Phillips case, supra, p. 22.
32. A Report to the President by the President's Materials Policy Commission (The Policy Report) June 1952, Volume III, Chapter 2, Natural Gas.

* * *

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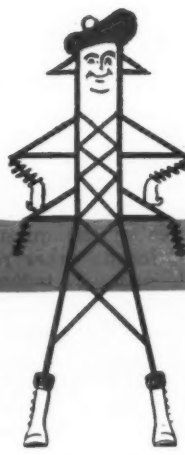

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ARAMCO OPERATIONS

Company now making rapid strides after war caused operations to cease for five years

V. S. SWAMINATHAN

In 1930 oil was discovered by Standard Oil Company of California on the Island of Bahrain, a famed pearling and ship-building center in the Persian Gulf. The shores of Saudi Arabia, barely 25 miles away, could be seen from Bahrain. The interests of geologists was keenly stimulated by petroleum possibilities in the mainland structures. Initial efforts of California Standard to obtain permission from King Ibn Saud to send a party of geologists to Saudi Arabia for reconnaissance were unsuccessful. At the time the Arabian King was suspicious of all foreigners. He was apprehensive of Italian and German political penetration, and of the aims of Britain in Palestine and France in Syria. By the middle of 1932, however, he had received favorable reports from the Sheikh of Bahrain about the operations of the Bahrain Petroleum Company (Bapco), and when California Standard sent representatives to Jeddah in the spring of 1933 they were accorded a friendly reception. On May 29 of the same year King Ibn Saud approved the concession agreement under which the Arabian American Oil Company (Aramco) is now developing the petroleum resources of the country. The Aramco concession covers some 440,000 sq miles, equalling in size the states of Texas and California combined. To get the rights the company agreed to pay the ruler four gold shillings for every long ton (22½ c. for every barrel) of oil it took out, and it also paid over 30,000 gold sovereigns to seal the deal.

Here follows an account of Aramco operations on its twentieth anniversary. Initial exploration work began in September 1933 when geologists landed at Jubail near Ras Tanura, and in December 1934 drilling crew landed at Al Khobar adjoining Dhahran. It was only in March 1938 that Damman No. 7, deep test, found oil in the Arab zone making commercial production possible. A start then was made with the installation of facilities. A year later barge shipments of crude oil to Bahrain Petroleum Company on Bahrain Island started. The first tanker shipment of Saudi Arabian crude oil was made in May, 1939, exactly six years after the signing of the concession agreement.

Aramco operations were virtually at a standstill between 1940 and 1945 due to the war, and most production increases of outstanding significance have been made since. In October 1940 the Ras Tanura terminal refinery of 3000 bbl per day capacity was completed to

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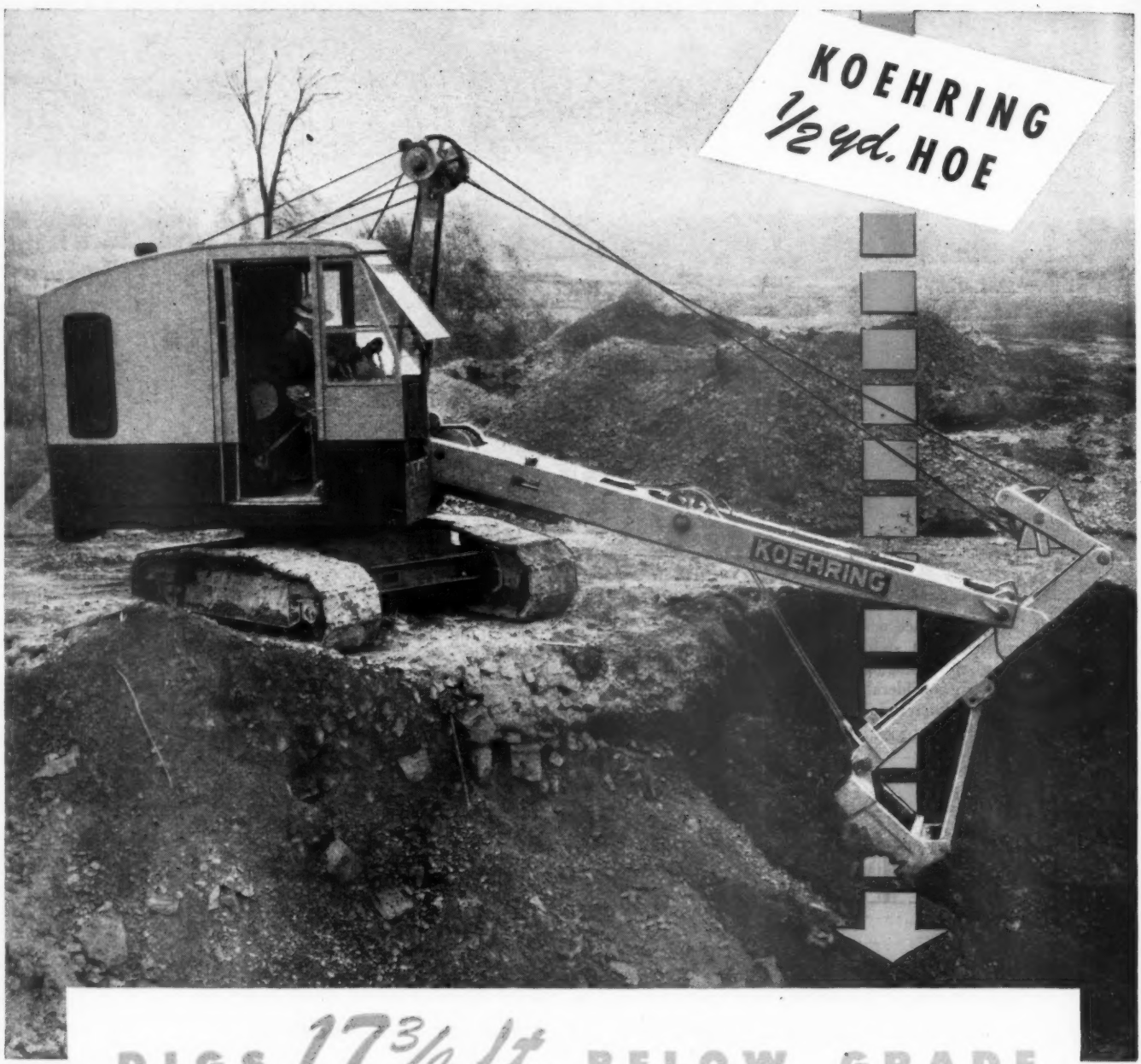

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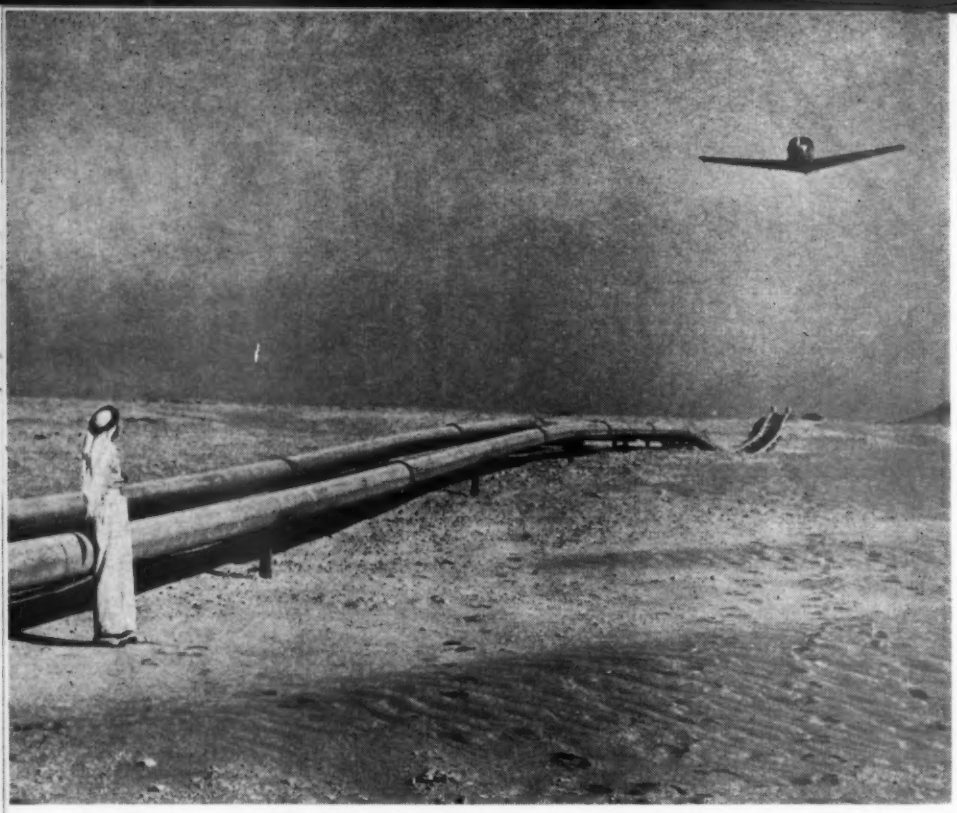

LIGHT plane checks small gage pipe lines near Dhahran, company's headquarters community eastern Saudi Arabia. To keep the many miles of pipe line traversing oil operational areas, Aramco makes use of both light planes and pipe line walkers. In this way, leakage or other pipe line defects can be easily spotted and quickly repaired.

supply products for local use. The following month marked the discovery of Abqaiq field in well No. 1, after location of high by structure drilling. In the early part of the war the American staff was reduced to about a hundred to support indispensable operations only. The 50,000 bbl per day Ras Tanura refinery was commissioned in September 1945. By following January initial Abqaiq field facilities were completed and in provisional operation. As a result Saudi Arabian crude oil production rose from 58,390 bbl per day in 1945 to 164,230 bbl per day the next year. In July 1948 the Ain Dar area of Ghawar field was discovered in the first well drilled, and production started six months later. When the Anglo-Iranian Oil Company's facilities in Persia were shut down by nationalization in June 1951 Aramco's production and refinery runs were stepped up to make up in part the loss of crude oil and refined products in markets of the free world. Production in 1951 averaged 761,500 bbl per day, of which 175,000 bbl per day was refined locally at the end of the year. Early in January 1952 Saudi Arabia passed a milestone in its petroleum history when the billionth barrel of crude oil was produced by the company. This epochal event followed 14 years of production and five years of previous exploratory effort. Last year Saudi Arabian crude oil production from four fabulous fields averaged 825,000 bbl per day. In the same year the company moved its headquarters to Dhahran.

Today Saudi Arabia is the third largest producer of oil in the free world after the United States and Venezuela, and Aramco is the world's premier petroleum producing company. In 1952 Aramco accounted for 825,000 bbl per day, and Creole Petroleum Corporation, 810,587 bbl per day, whereas in 1950 it ranked third with 546,700 bbl per day, after Creole (685,839 bbl per day) and Anglo-Iranian (665,400 bbl per day from Persia). At the beginning of 1953 Aramco's reserves stood at 16 billion barrels, being exceeded only by U. S. A. (29 billion barrels), and Kuwait (20 billion barrels).

Other Companies' Operations

Aramco agreed to relinquish sections of the concession area gradually after exploration, and the area now remaining in its concession has been reduced according to this undertaking. In 1936 The Texas Company acquired a half interest in these concessions and the operating company became the California Arabian Standard Company. In 1944 this name was changed to Arabian American Oil Company (Aramco). Three years later Standard Oil of New Jersey and Socony-Vacuum became partners in the enterprise. Objections to this by the French members of the Iraq Petroleum Company, to the effect that it represented an infringement of the 1928 Red Line Agreement, were settled, and this latter pact was ended in 1948. In the same year Aramco relinquished preferential rights over a part of Saudi Arabia west of 46 E and over the Saudi Arabian interest in the Kuwait Neutral Zone. Today Socony-Vacuum has a 10 per cent interest in the company and the other partners each have a 30 per cent interest. In fine, Saudi Arabia is the only large kingdom in the Middle East where oil exploitation is being carried out entirely by American capital.

The eastern part of the Arabian Peninsula is a sedimentary foreland-shelf area sloping off north-east into the Mesopotamia (or Persian Gulf) geosyncline. The Aramco concession covers over 400,000 sq miles in the eastern sediment-covered part of the territory. It is under the coastal belt of the Tertiaries bordering the Persian Gulf that all the Arabian oil fields have been found. One field, Safaniya, was brought in during 1951 from an offshore location 3 km out in the Gulf. Only one Arabian field, Dammam, the first discovery in the mainland, has a clear surface expression—an Eocene window surrounded by Miocene. All the other fields, except perhaps Qatif, revealing some surface indication, entailed an intensive program of geophysical exploration and/or structure drilling before their discovery.

Dammam is an oval shaped dome with axes approximately 5 and 4 miles long. Abu Hadriya is a circular dome determined by surface and seismic mapping and structure drilling. The subsurface structure awaits clear delineation. The productive area of Abqaiq is 30 miles long and 8 miles wide. Qatif, an elongated anticline barely discernible on the surface was confirmed by structure drilling. The field is 9½ miles by 2 miles. Ain Dar, an elongated anticline with a north-south trend, was determined by structure drilling. Its productive area equals that of Abqaiq. Fadhili's structure was ascertained by structure drilling, while its subsurface structures have not yet been clearly delineated. Haradh is an irregular dome as determined by structure drilling, and confirmed by a gravity meter-survey. Its productive area may be about 12 miles by 8 miles, but its subsurface structure is yet to be defined. Uthmaniyah is an irregular dome determined by structure drilling, and confirmed by a gravity-meter survey. Proved productive area is approximately 10 miles by 2 miles. Safaniya is a brachyanticline determined by gravity-meter survey, supplemented by structure drilling and surface mapping. The subsurface structure has not yet been clearly delineated.

The first oil in Arabia was discovered in August 1936 at Dhahran (Dammam field). The zone encountered was at the same stratigraphic position as at Bahrain, but oil was not found in paying quantities. The results of drilling nine additional wells elsewhere on the structure, involving an outlay so far of $3,000,000, were very discouraging. Later on, however, by drilling 2000 ft deeper more prolific zones were discovered in Upper Jurassic limestones, and commercial production became a certainty when a well was brought in on August 30, 1938.

Abqaiq No. 1, the discovery well was situated in a broad belt of moving sand dunes after an extensive structure drilling program had indicated the presence of an anticlinal structure. It was spudded in August 1940. From 1941 through

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1945 the drilling group managed to complete five Abqaiq wells and suspend a sixth because of a bad fishing job. By mid-1947 six new diesel operated rigs were active, five being devoted to development operations. Drilling ceased at the end of 1950 with the completion of 66 wells. As the basic shape and extent of the main structure became evident plans were adopted for developing the field by drilling wells on a given contour or ring around the anticline, while in the flat northern area spacing of wells approached the block pattern.

Abqaiq oil is obtained from limestone (probably of Upper Jurassic age) interbedded with bodies of anhydrite. The same formations are well recognized in the majority of Saudi Arabian oilfields, and are known as the Arab zone. The anhydrite layers divide this zone into four members designated from top to bottom as A, B, C, and D. Commercial production in Abqaiq field is found only in the C and D members, and the C member is relatively unimportant. It is produced only near the top of the structure in an area 9 miles by 2½ miles. Production from portions of the D zone takes on some of the aspects of drawing the oil from the tank.

The Ain Dar area of the Ghawar field was discovered in July 1948 in the first well drilled confirming expectations from subsurface exploration work, and initial production began in January 1951. The entire Ghawar field forms one of the world's greatest oil accumulations. Uthmaniyah is the southernmost of three producing areas situated in a rough triangle within the so-called Greater Ghawar field. To the northeast is the new Shedgum area, while Ain Dar is to the north of Uthmaniyah. Nearly 62 miles separates the northern end of Ain Dar from the present southernmost wells in Uthmaniyah. The Uthmaniyah and Shedgum areas have not yet been developed to a point where accurate estimates of their size can be made.

Aramco's 1952 crude oil output of 824,756 bbl per day came from the four producing fields thus: Abqaiq 422,000 bbl per day, (51 per cent), Dammam 63,000 bbl per day (8 per cent), Ghawar-Ain Dar 305,000 bbl per day, (37 per cent), and Qatif 35,000 bbl per day, (4 per cent). The leading characteristics of unstabilized Aramco crude oil are summarized below:

	Gas/oil ratio std cu ft/bbl	API gravity	Reid vapor pressure	Viscosity SUS at 70 F	Hydrogen sulfide ppm
Dammam..	460	35.0	4.0– 5.5	49.0	75–200
Qatif.....	525	35.0	8.0–10.0	55.0	650–850
Abqaiq....	875	37.5	6.5–10.0	44.5	125–350
Ghawar-Ain Dar..	610	35.0	6.5– 8.5	54.0	75–200

The 10,000-ft deep Abu Hadriya field has not been brought into production as shallower output to meet all needs has been found nearer to the refinery and terminal at Ras Tanura. Four more proved areas—Haradh, Fadhili, Safaniya, and Ghawar-Shedgum—have not been brought into production. Ghawar-Uthmaniyah began producing early in 1953.

Oil drilling, producing, and processing problems in Arabia differ from those in the United States. They stem from the necessity of employing national operators, the characteristics of the crude oil and the conditions under which operations must be conducted. Competitive drilling has no place here. When men, materials, and supplies, both for actual operations and supporting facilities must be transported halfway around the world it is obvious that not a foot of hole could be wasted. Well spacing is a compromise between the need for exploration to define and outline the structure, and requirements for development wells so as to insure the most efficient over-all production of the reservoir. It is the reservoir engineering problem and that of accounting for production which render the gaging of separator-station output, or individual field production, necessary. Royalty gaging is done only at Qaisumah where oil is delivered to the Trans-Arabian Pipeline Company; at Ras Tanura where it is refined and also shipped offshore in tankers; and at Dhahran from where it is pumped through underwater pipe line to the Bahrain Petroleum Company's refinery on Bahrain Island. At these three locations, a total of 28 royalty gaging tanks is provided with a net working capacity of 3,800,000 bbl per day. At normal production rates well-head pressures of 500-800 psi or more are common. In all locations the terrain is such that long

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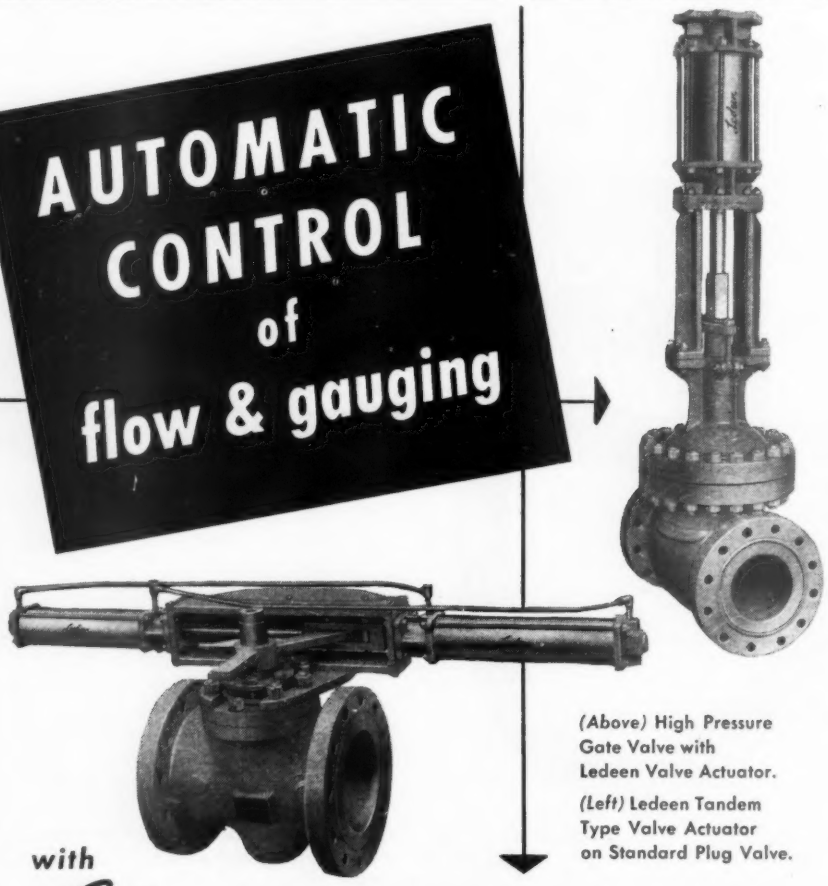

(Above) High Pressure Gate Valve with Ledeen Valve Actuator.

(Left) Ledeen Tandem Type Valve Actuator on Standard Plug Valve.

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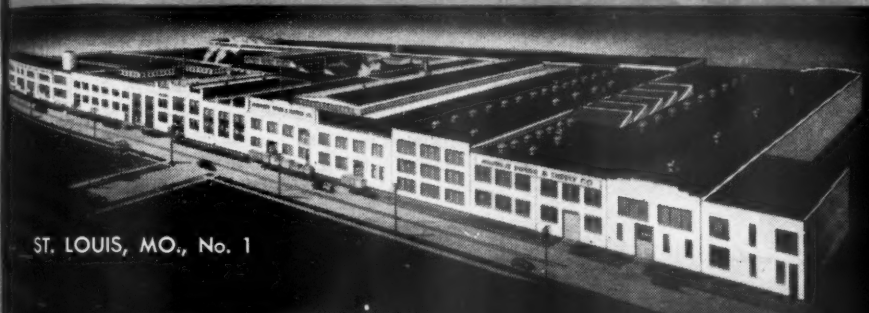

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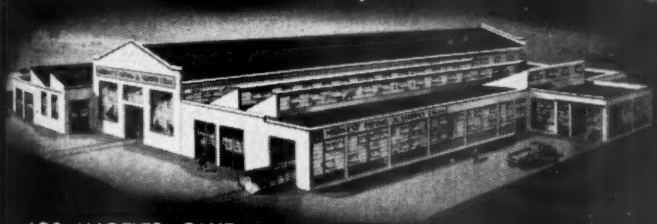

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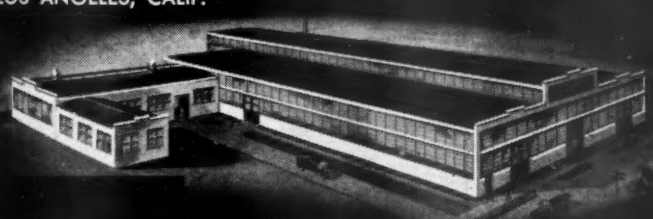

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flow lines present no insuperable difficulties. All these factors make for a concentration of field facilities, resulting in central separating plants with capacities as large as 200,000 bbl per day, and a thermal stabilizer for hydrogen sulfide removal of over 500,000 bbl per day.

In the Dammam field there are 23 producing wells within the proven area. A 200-250-acre minimum rectangle spacing was used and the wells are no closer than 1500 ft nor farther apart than 3700 ft depending on fault conditions. Gas-oil separation is done at a central station of 90,000 bbl per day capacity situated near the midpoint of the field, 12,000 ft from the most distant well.

The 9 producing wells in the Qatif field are confined to exploration holes along the axis and on a middle and northern cross-section. Spacing between wells ranges from 5000 to 10,000 ft. Three small separating stations of 20,000 bbl per day capacity are provided along the axis of the field, and the maximum length of flow line has been held to 10,000 ft.

Except for a low-relief northern tip the Abqaiq field is now completely developed with 62 producing wells. It has three gas-oil separating stations, one in the flat northern area and two in the main part. The latter two stations each have two separating units nominally rated at 100,000 bbl per day apiece. The northern station has a single similar unit for a separator capacity of 50,000 bbl per day. Flow lines into these stations from the outlying wells may be as long as 30,000 ft.

The Ghawar-Ain Dar area was discovered in July 1948. At the end of 1952 some 45 wells were producing from a proven area of the size of Abqaiq field. Spacing between wells is about 10,000 ft. Ain Dar wells are flowed into four central gas-oil separating stations, each with one separating unit of 100,000 bbl per day rated capacity, and maximum lengths of flow lines are under 25,000 ft.

Separators

The first Aramco separators made use of horizontal gravity-type separating vessels, and they have proved most effective for achieving high-rate gas-oil separation. Whereas in the case of Dammam separator development was tied to the needs of stabilization facilities, at Abqaiq and Qatif the initial separators were developed to provide a degassed oil which, although sour, was of low enough vapor pressure to be pumped and stored with a minimum of hazard.

The fifth 100,000 bbl per day Abqaiq unit, installed at No. 3 gas-oil separator plant, is the fruit of five years' continuous improvement in high-grade horizontal separator design. Single horizontal vessels 120 ft in length were used in each of the first three stages of the fifth unit. Dual motor valves, sized for high overloads, were employed for the first time in all essential services. Locked plug cocks were provided under each relief valve. Protection against high level and liquid pressuring of any vessel was provided for by a two-element (level and pressure) controller which closed an emergency valve on the inlet of the high pressure trap. In addition, emergency flow-line shutoff valves were provided. Much work on back pressure control led to the installation of dual, angle-type valves plus a bypass for each stage. Other improvements were the adoption of overhead lines to prevent the accumulation of wind-blown sand, and a buried header type of flare tip designed to reduce the smoke and glare nuisance. Because of the many improvements incorporated in the fifth Abqaiq unit, No. 3 gas-oil separator plant was the first installation which did not require full-time American supervision. It marked a milestone toward the Aramco goal of maximum Saudi Arab participation in operation of the oil enterprise.

In addition to these desirable simplified operating features, the Ain Dar installations incorporate some characteristics of their own. One of these is aboveground flow lines which, by realizing air cooling averaging 35 F over the year, effect a worthwhile conservation of resources. Several economies have been achieved in the design of Ain Dar No. 4 gas-oil separator plant by eliminating dual control valves in all gas and oil services as well as dual relief valves and the inlet shutoff valve on the high pressure trap, and deletion of multiple

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TURNING out skilled drilling rig employees is job of an instructor. Here he works with Saudi trainees on a dummy rig set up on outskirts of Dhahran, Saudi Arabia. Trainees are learning nomenclature of many parts and instruments involved in oil well drilling.

SAUDI ARAB villagers take advantage of a water source near an Arabian American oil well drilling rig in desert. Location is in Ain Dar region of eastern Saudi Arabia. Scenes both pastoral and industrial set side by side are a familiar sight in present day.

flare lines. Recent gas-oil separator plant installations, complete with pumping facilities and utilities, but excluding flow lines, have been costing nearly $1,500,000. It is expected that Ain Dar No. 4 gas-oil separator plant will be significantly less expensive. For purposes of comparison with United States costs broadly speaking Arabian construction costs are twice those in America. Offsetting this, however, operating costs of such an installation are correspondingly low, a recent average figure being approximately $3 per 1000 bbl, including cost of repairs.

Future gas-oil separator plant improvements hinge on the application of centrifugal separating principles. They have been applied in some small, vertical separators and are embodied in the tangential inlets on Anglo-Iranian units at Agha Jari. A small high acceleration unit patented by Aramco has shown some promise, but has not yet been carried to the point of full-scale application. A vane element placed in the nozzle of one horizontal test trap in Abqaiq resulted in a capacity increase of 70 per cent. Experiments are being continued along these lines. Another possibility under study is the employment of smaller capacity central stations to realize savings in well and flow-line costs. Finally, unattended stations and entirely electrified installations are also deemed promising possibilities.

No segregation of Arabian crudes of different gravity is attempted, but by taking advantage of inherent pipe line flexibility it has been found possible to equalize the gravity of stabilized crude at all outlets. Stabilization reduces the vapor pressure to 3.0-3.5 Rvp, with a loss in gravity of less than 1.0 API. Hence sour crude shipped offshore via pipe line is held 0.7 to 1.0 deg API higher in gravity than stabilized crude for tanker haul from Ras Tanura or deliveries to Tapline for offtake at Sidon.

Additional crude processing in the field is provided for in stabilizers, which are atmospheric weathering columns having steam-heated reboilers, designed to remove propanes and the lighter hydrocarbons from crude oil. Removal of propane also effects satisfactory removal of hydrogen sulfide. The degree of weathering is controlled by regulating the steam rate to the reboilers, which in turn controls the bottom temperature. The reduction of vapor pressures accompanying stabilization is sufficient to prevent evolution of excess hydrocarbon vapors and the resultant explosion hazard. Stabilizers are installed at Dhahran, Ras Tanura (in the refinery) and Abqaiq with rated capacities of 175,000, 85,000 and 54,000 bbl per day respectively. With the dismantling of the two 7-ft Dhahran stabilizer columns late in 1952 and their removal to Ras Tanura for use as part of a new crude topping unit the Dhahran stabilizer capacity is now reduced to 115,000 bbl per day. It feeds oil produced from Dammam field, plus a certain amount from Abqaiq and/or Ain Dar. All of the stabilized Qatif output is stabilized at Ras Tanura plus some Abqaiq and Ain Dar crude. The Abqaiq stabilizer feeds only production from Abqaiq and Ain Dar.

The Abqaiq stabilizer units were built principally to process slightly upwards of 300,000 bbl per day of oil for shipment through Tapline. With modifications completed in 1951 including extra bottom coolers and larger pumps, they now handle nearly twice this amount and can supply a major proportion of the Ras Tanura offshore needs as well. There are four columns 12-ft 6-in. by 46-ft 6-in. Two have one-half crossflow trays; the other two have one-quarter crossflow trays designed for high liquid traffic. Abqaiq columns are designed for a nominal 50 psi permitting operation of the stabilizer at 20 psi, which is planned upon completion of the gas injection facilities late in 1953. Higher pressure operation is reckoned to show a recovery of 45 per cent of the pentanes now lost to the flare when the feed is from tankage and 65 per cent when feed is taken directly from the low-pressure traps. An increase in the column pressure involves, however, some slight loss in capacity. Several methods of regaining this loss are under investigation. One is the development of controls that will allow operating the reboiler at the minimum temperature necessary to meet the hydrogen sulfide specification. At present, with an allowable 10 ppm H_2S content, the average product test is less than 5 ppm.

Another facet of the crude oil handling problem related to stabilization is that of storage facilities. Field storage of both stabilized and sour crude is accomplished by means of floating roof tanks. It was at one time thought that the unstabilized oil would require additional separation in a vessel operating below atmospheric pressure. Experi-

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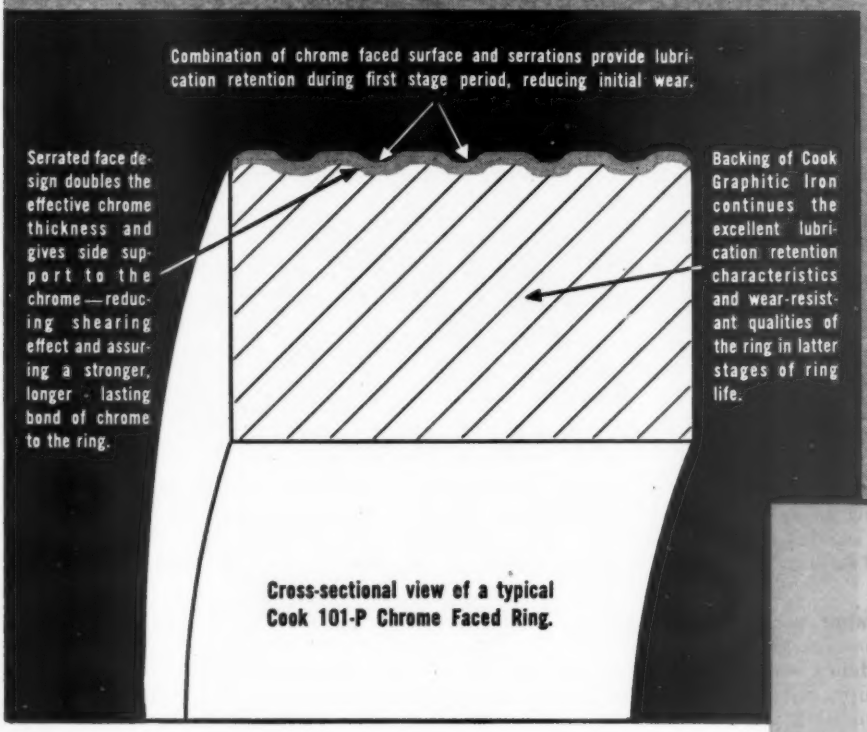
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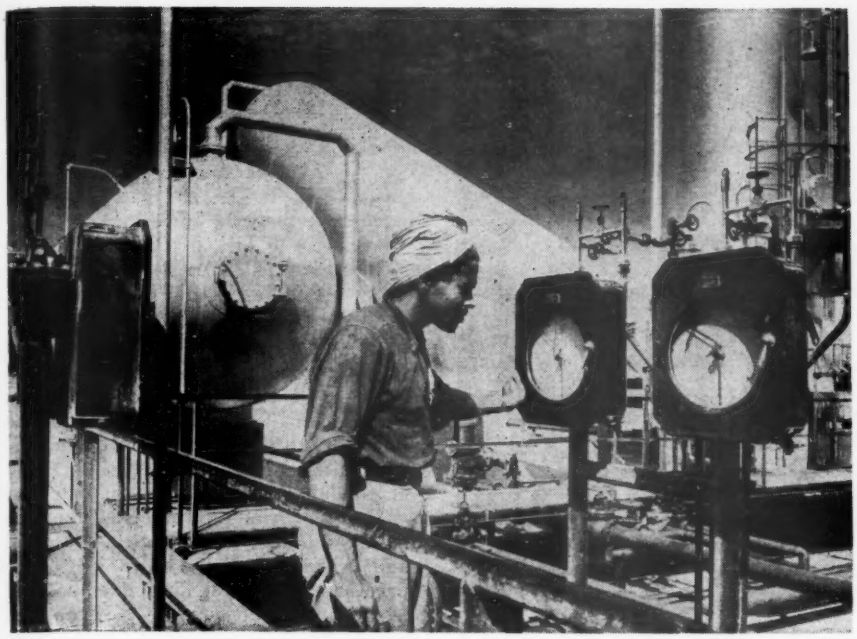

One of the skilled Saudi Arab refinery employees logs instrument readings at Ras Tanura refinery. Aramco employs 15,000 Saudis in all phases of its oil operations in Saudi Arabia. Many of these employees were once camel herders and desert tribesmen and through training programs have advanced to responsible technical jobs.

ments were carried out to determine quantitatively the extent of the hazard involved in floating roof storage. And when it was proved that the hazard was not sufficiently great to warrant additional crude processing, work on the subatmospheric trap project was abandoned. It is very likely that the cone roofs of the first sour-crude storage tanks will be replaced, where necessary, with floating roofs.

A significant final step in processing Arabian crude now under way is the pressure maintenance program at Abqaiq. The gas-injection unit will return 150,000,000 std cu ft per day to the formation in this field. Cost of this project, scheduled for completion before the end of 1953, is approximately $20,000,000. The new plant will replenish the reservoir to the extent that such ultimately recoverable light ends are replaced. And gas disposal, as it has been practiced since the start of production, will have become a thing of the past.

Several major facilities were completed and put into operation in 1952, i.e., five new gas-oil separator plants; a 78-km 30-31-in. line between Uthmaniyah and Abqaiq; a booster station at Wariah on the company's 30-31-in. Qatif-Qaisumah line, and an additional under-water line to Bahrain. Two of the five new gas-oil separator plants were constructed in the Ain Dar area making a total of four in that field. The first separator plant was installed at Uthmaniyah, and two small separator plants were completed in Qatif field making a total of three there. The commissioning of the Wariah booster station in August 1952 increased the capacity of pipe line from Wariah to Qaisumah by 10,000 bbl per day rendering it more flexible and enabling Tapline to pump at full capacity at all times. Flow lines totalling 98 km in length were completed to tie in 19 new wells for the gas-oil separator plants. An additional 26 km 12-in. line went into operation between Saudi Arabia and Bahrain in November 1952 to supplement the existing pipe line.

Forty new wells were completed in 1952, 17 in Ghawar-Ain Dar area, 2 in Ghawar-Shedgum area, 15 in Ghawar-Uthmaniyah and 6 in Safania. Of 214 wells completed by the end of last year 129 were producers. At the end of 1952 seven drilling rigs were in operation and they were reduced to six last January. Last year Aramco was active in the field of exploration surveys with mapping parties operating in north Hasa and northwestern part of the concession. In north Hasa there was also a triangulation party, two structure parties and a gravity meter party. In the vast sand area to the south called Rub 'al Khali there was a triangulation party, two gravity meter parties and a structure drilling party.

Early in 1953 the Uthmaniyah area was brought into commercial production following the construction of a 30 and 31-in. pipe line to Abqaiq and completion of separator facilities. This pipe line is providing close on 100,000 bbl per day to Aramco's total of approximately 800,000 bbl per day. Twelve wells are now tied into the separator plant in the northern end of the area. The 30 and 31-in. line is running some 200,000 bbl per day consisting of Uthmaniyah crude and another 100,000 bbl per day through a connection with Ain Dar separator plant 4 completed in the fall of 1952. There are now 26 completed wells in Uthmaniyah where development is under way on the characteristic ring pattern. The Ghawar-Shedgum area, with 7 completed wells and 2 rigs running, is still in an early stage of development. The company is expediting the development of off-shore Safania field. There are 11 completed Safania wells, all but 2 offshore.

The Greater Ghawar field now (March, 1953) accounts for slightly more than half of Aramco's total production. In addition to the 200,000 bbl per day through the 30 and 31-in. pipe line, another approximately 225,000 bbl per day is being moved out of the three northern Ain Dar separator plants through an older 20, 22, and 24-in. line extending east into Abqaiq. For its remaining output the company is drawing 280,000-290,000 bbl per day from Abqaiq, 40,000 bbl per day from Qatif and 65,000 bbl per day from Dammam.

Aramco's oil disposition in 1952 is given below:

	Bbl per day	Per cent
Crude oil pumped to Bahrain	130,171	16
Crude oil loaded at Ras Tanura	208,977	25
Crude oil pumped to Tapline	309,274	38
Crude oil run to stills	169,957	20
Crude oil used, sold and in closing inventory	6,377	1

During the early years of discouraging drilling Aramco men were learning the language and lore of Arabia. They were also building new facilities. They erected a materials receiving pier, brought in equipment, constructed houses, developed sources of water supply, set up repair facilities for motor vehicles, established medical facilities and telephone communications, built shops and warehouses. And discovery of oil posed the problem of getting it to the market. Tanks were built, and a pipe line laid for 39 miles northward to Ras Tanura. Offshore loading facilities were taken in hand to permit loading of crude oil into ocean going tankers. In the meantime oil was piped to Al Khobar and barged to Bahrain Island. The second World War retarded the rapid emergence of Saudi Arabia as a major oil producer. By mid-1942 Aramco's staff had shrunk from some 400 to a mere 100. Geological parties were pulled in from the desert and drilling ceased. Wells were capped and only a trickle of oil continued to move by barge to Bahrain. Since then Aramco has grown up in a hurry. Thus crude oil production rose from 58,390 bbl per day in 1945 to 164,230 bbl per day the following year to 824,756 bbl per day in 1952. In January 1952 Aramco accounted for the billionth barrel of crude oil.

In October 1940 the Ras Tanura terminal refinery of 3000 bbl per day capacity was completed to supply products for local use. A modern 50,000 bbl per day capacity refinery was conceived, built, and brought into operation by the company in September 1945 at a cost of $70,000,000. The U. S. military authorities assisted Aramco with priorities for critical raw materials. During the early stages of construction a complete cargo of equipment and plant was sunk by enemy action. The refinery was completed in time to contribute appreciably to post-war operations of naval and

PIER'S END at Dammam, Saudi Arabia. This western terminus of Saudi Government Railroad is busy off-loading point for many freighters each month which load their cargoes onto railroad cars to be shipped inland. Dammam is Persian Gulf port where Saudi Arab government has constructed a 7-mile long causeway and trestle. This provides deep-water anchorage at a well equipped wharf for ocean-draft ships which could not dock in shallow waters of Arabian mainland.

military forces in the Pacific. It had atmospheric and vacuum distillation units, reforming capacity and naphtha re-run plant. By 1947 its capacity was stepped up to 125,000 bbl per day and is now approaching 200,000 bbl per day. A new 22,000 bbl per day topping plant and a catalytic polymerization unit are scheduled to be in operation by the end of 1953. An asphalt plant was added in 1952, and it produced over 200,000 bbl that year. Refinery output of major products in 1950 and 1951 were:

	(In 1000 Barrels)	
	1951	1950
Motor spirit	12,146	8,350
Kerosine	4,675	2,947
Distillate fuel oil	13,294	10,542
Residual fuel oil	26,108	15,738
Total	56,853	37,577

The Ran Tanura refinery ran an average of 169,957 bbl per day in 1952.

Most of the charge for Bahrain Petroleum Company's large refinery of about 200,000 bbl per day comes from Saudi Arabia. This crude is moved to Bahrain by submarine pipe line whose underwater section was looped toward the end of 1952. This had made unnecessary the supplemental tanker movements of Arabian crude taking place before.

Early in 1944 a recommendation was made by U. S. military authorities for the construction of a pipe line from the Persian Gulf to the Mediterranean as a project of the wartime Petroleum Reserves Corporation. This proposal did not materialize, but Aramco's parent companies which, through subsidiaries, are responsible for the marketing and distribution of Saudi Arabian oil, eventually built this line. Entailing an outlay of $230,000,000 this 1068-mile, 30 and 31-in. Tapline, with six pump stations, connects Saudi Arabian oilfields to Sidon in Lebanon on the Mediterranean. It is the largest single undertaking ever carried out by private American capital in oil or any other industry. Since September 1950 when the Tapline was opened to the end of that year 9,260,000 bbl of Arabian oil moved into it thus eliminating Suez Canal dues. Any given number of tankers available for moving Saudi Arabian crude oil can now deliver at least twice as much to European ports by loading in the Eastern Mediterranean instead of at Ras Tanura port. The tanker round trip to Britain, for example, takes 18 days running time at sea instead of 36 days and to Marseilles 9 days at sea instead of 26. The Tapline has in effect moved the Arabian oilfields some 3500 miles closer to the important markets of Western Europe.

Tapline's pumpings in 1952 averaged 312,940 bbl per day and liftings at Sidon terminal, 309,274 bbl per day. During that year 992 ships loaded at the terminal with an average cargo of 114,107 bbl and a mean loading rate of 15,145 bbl per hour. The expansion of the terminal was completed with the addition of four 180,000 bbl tanks, bringing the total crude storage to twenty 180,000 bbl tanks, and one 25,000 bbl tank. Also three 100,000 bbl tanks were commissioned for storage of bunker and diesel oil. In addition a fifth submarine berth was added giving the terminal a peak loading capacity of approximately 1,000,000 bbl per day. Finally, the installation of vertical booster pumps in the line where it enters three of the pump stations has reduced the incoming pressure to a minimum and permitted adjustments in pumping schedules resulting in an increase of 4000 bbl per day throughput.

Estimated demand for petroleum products in Saudi Arabia during 1950 and 1951 is given below:

	(In 1000 barrels)	
	1951	1950
Estimated demand:		
Motor spirit	715	733
Kerosine	52	47
Lubricating oil	13	12
Distillate fuel oil	1,520	1,652
Residual fuel oil	8,056	8,463
	10,356	10,907

Domestic demand for oil products shows a general upward trend. Several bulk plants have been erected. One at Dhahran loads out 150 to 175 railroad tank cars to interior parts every month. The initial units of a large bulk plant at Jeddah were recently completed, as well as a marine terminal. In June 1952 the first tanker called at this terminal and delivered 113,000 bbl of petroleum products. Bulk distribution is handled by Aramco who provide assistance to Saudi Arabian dealers in establishing retail service stations. A diesel-powered railroad built for King Ibn Saud by the company links Riyadh the capital with the rapidly developing east coast. Asphalt from Ras Tanura refinery is being used to construct a network of modern roads connecting the main focal points of operation.

Under the original concession Aramco was obliged to pay royalties of four gold shillings per long ton of oil. At the official price of gold this is equivalent to $8.24 per sovereign (gold pound) or 22½ cents a barrel. Early in 1949 the company agreed to pay royalty, as a compromise measure, on the basis of $12 per sovereign or 32 cents a barrel, thus meeting the Saudi Arabian Government half-way, which contended that royalty should be based on the price of gold prevailing in Arabia. The supplemental agreement of December 30, 1950 resolved a number of long-standing problems between the two parties. Its most important feature is provision for payment to the Government of a share in Aramco's net operating revenues in the country. The Saudi Arabain Government receives in the form of royalties and participation in profits an amount equal to 50 per cent of the net operating revenues, i.e., of the balance arrived at by deducting from gross receipts the operating expenses, depreciation, exploration, and development expenses and foreign government taxes including U. S. income taxes. The amount thus arrived at is to stand in lieu of all previous payments, including royalty, income tax, import duties, visa fees, and port charges. Payments by the company may not fall below the fixed rate of royalty plus taxes previously paid. The exact basis for the valuation of oil products and calculation of net operating revenues has not been disclosed. Another important provision is that monetary transactions between the Saudi Arabian Government and the company will be carried out at the internationally accepted rates of exchange, and that payment to the state

can be made in any currency Aramco receives and in the same proportion that the receipts of such currency bear to total receipts. Under the terms of the new agreement the Saudi Arabian Government is taken to receive 55 cents a barrel. On this basis its 1950 receipts are estimated at $110,000,000 ($45,000,000 more than it would have been entitled under the previous agreement) as against $55,000,000 in 1949. Its receipts for 1951 and 1952 are placed at $155,000,000 and $166,000,000 respectively.

Before the discovery and exploitation of oil in enormous quantities Saudi Arabia was a poor country largely isolated from the rest of the world but for annual visits of pilgrims to the holy cities of Mecca where Mohammed was born and Medina where he is buried. The $7,000,000 odd these pious travelers paid into government coffers kept the country going. And the occupations of its people changed hardly at all through countless generations until recently. They were soldiers, merchants, and craftsmen, date growers and Bedouins who spent their lives wandering across the desert in search of forage and water. Aramco operations and wealth from petroleum are transforming Saudi Arabia from medieval to a cautiously progressive modern state. Thousands of Arabs brought in from desert and town from all parts of the vast, sparsely peopled Peninsula have been introduced to a new means of livelihood and living standards they had never known before. When the Americans first arrived these people were shown the mysteries of such new fangled gadgets as the wheel barrow and monkey wrench. Now hundreds are operating machine shop lathes, welding torches and tools; repairing engines, doing electrical wiring and running tests in the laboratories. A raw recruit starts on a wage of 80 cents a day and he has plenty of opportunities of improving his status. Over 13,000 Arabs are now in the employ of Aramco.

Moreover hundreds of Aramco men are carrying out a miniature Point Four Program in Arabia financed from oil income. It involves large-scale railroad construction, expansion of port facili-

Table 1.

Field or area	Stages of separation	Production vessels and separating pressures — Stage 1	Stage 2	Stage 3	Stage 4	Rated capacity bbl/day	No. of wells connected	Flow lines — Size (in.)	Flow lines — Max. length (ft)
Dammam —									
Dammam central traps:									
Unit 1–Sept. 1938...	4	Six 3 × 16 ft vertical in parallel at 335 psi	Two 5 × 12 ft vertical in parallel at 140 psi			10,000			
Unit 2–Jan. 1941.....	4	Six 3 × 16 ft vertical in parallel at 335 psi	Two 5 × 12 ft vertical in parallel at 140 psi	Four 9 × 30 ft horizontal in parallel at 60 psi	10,000-bbl spheroid or thermal stabilizer at 2-3 psi	10,000	23	4	12,000
Unit 3–Aug. 1945....	4	Two 4 × 60 ft horizontal in series at 300 psi	Two 4 × 60 ft horizontal in series at 140 psi			70,000			
Qatif —									
Qatif G.O.S.P. No. 1 Unit No. 1–July 1945	3	Two 3 × 16 ft vertical in parallel at 250 psi	One 5 × 16 ft vertical at 50 psi	45 × 40-ft 11,000-bbl cone-roof tank at 5 in. H_2O		2,000	Converted for well testing in 1948		
Unit 2–Feb. 1948.....	3	One 4 × 60 ft horizontal at 250 psi	One 9 × 60 ft horizontal at 50 psi	45 × 40-ft 11,000-bbl cone-roof tank at 5 in. H_2O		20,000	Orig. 4 Now 2	4 & 6	17,000
Quatif G.O.S.P. No. 2 –Jan. 1952	3	One 4 × 40 ft horizontal at 250 psi	One 4 × 40 ft horizontal at 30 psi	5,000-bbl cone-roof tank at 1–1½ psi		20,000	4	4	6,000
Quatif G.O.S.P. No. 3 –Feb. 1952	3	One 4 × 40 ft horizontal at 250 psi	One 4 × 40 ft horizontal at 30 psi	5,000-bbl cone-roof tank at 1–1½ psi		20,000	3	4	10,000
Abqaiq —									
Abqaiq G.O.S.P. No. 1 Unit No. 1–May 1946	4	Three 4 × 60 ft horizontal in parallel at 500 psi	Two 4 × 60 ft horizontal in parallel at 150 psi	Three 9 × 60 ft horizontal in parallel at 65 psi	10,000-bbl spheroid at 5 psi or thermal stabilizer at 20 psi	75,000			
Unit 2–Sept. 1947...	4	One 5½ × 120 ft horizontal at 500 psi	One 5½ × 120 ft horizontal at 150 psi	One 9 × 120 ft horizontal at 65 psi	10,000-bbl spheroid at 5 psi or thermal stabilizer at 20 psi	80,000	30	4 & comb. 4–6	30,000
Abqaiq G.O.S.P. No. 2 Unit 3–April 1948	4	One 5½ × 120 ft horizontal at 500 psi	One 5½ × 120 ft horizontal at 150 psi	One 9 × 120 ft horizontal at 50 psi	10,000-bbl spheroid at 5 psi	100,000			
Unit 4–Nov 1948	4	One 5½ × 120 ft horizontal at 500 psi	One 5½ × 120 ft horizontal at 150 psi	One 9 × 120 ft horizontal at 50 psi	10,000 bbl spheroid at 5 psi	100,000	20	4 & comb. 4–6	27,000
Abqaiq G.O.S.P. No. 3 –May 1950	4	One 6 × 120 ft horizontal at 500 psi	One 5½ × 120 ft horizontal at 150 psi	One 9 × 120 ft horizontal at 50 psi	10,000-bbl spheroid at 5 psi	100,000	12	4 & comb. 4–6	30,000
Ain Dar —									
Ain Dar G.O.S.P. No. 1 –Jan. 1951	3	One 6 × 120 ft horizontal at 300 psi	Two 9 × 60 ft horizontal in parallel at 50 psi	10,000-bbl spheroid at 5 psi		100,000	10	6	19,000
Ain Dar G.O.S.P. No. 2 –Oct. 1951	3	One 6 × 120 ft horizontal at 300 psi	One 9 × 120 ft horizontal at 50 psi	10,000-bbl spheroid at 5 psi		100,000	11	6 & comb. 6–8	24,000
Ain Dar G.O.S.P. No. 3 –Jan. 1952	3	One 6 × 120 ft horizontal at 300 psi	One 9 × 120 ft horizontal at 50 psi	10,000-bbl spheroid at 5 psi		100,000	12	6 & comb. 6–8	24,000
Ain Dar G.O.S.P. No. 4 –Oct. 1952	3	One 6 × 120 ft horizontal at 300 psi	One 9 × 120 ft horizontal at 50 psi	10,000-bbl spheroid at 5 psi		100,000	12	6 & comb. 6–8	26,000

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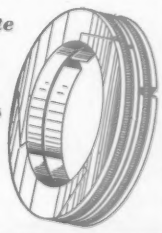

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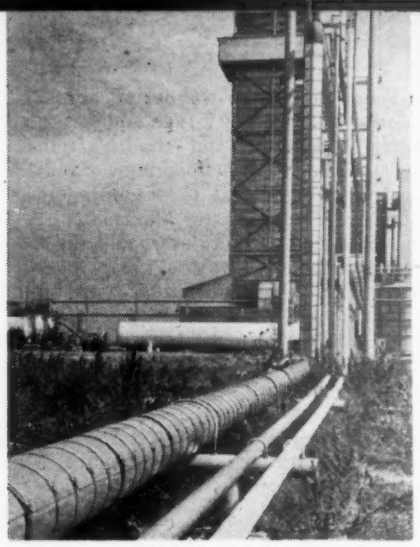
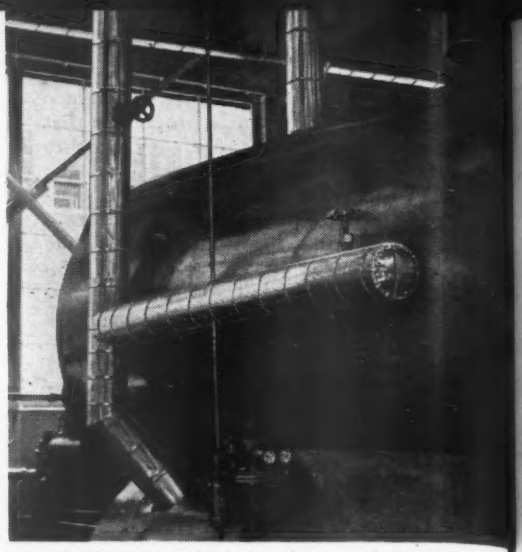
This big new Oklahoma refinery has used a new kind of aluminum jacketing throughout on both insulated lines and towers and vessels. Light in weight and low in cost, this new Childers Aluminum Jacketing cut installation costs. It is also expected to cut maintenance costs.



Childers Aluminum Jacketing is used here on a cross-country transfer line at a large chemical manufacturing plant in Texas. This is a rugged test for any jacketing, but the light-weight aluminum used in this jacketing should stand up to weather and chemical corrosion it encounters.



"Good Housekeeping" is the word in this gas pipeline pump station. The insulated lines are handsomely protected by Childers Aluminum Jacketing, which should last as long as the plant itself. The jacketing requires no painting and very little other maintenance. It even allows the interior of the plant to be washed with a hose without harm to the insulation. The chief engineer reports: "We have standardized on Childers Jacketing for all our insulated lines. It is doing an excellent job for us and saving us money."

How 5 plants cut costs of jacketing insulated lines

Weather-resistant, low-cost, easy to put on—these are big reasons for the growing popularity of a new jacketing, specially engineered for insulated lines. It is made of .006" thick aluminum and comes with or without a moisture barrier. It is called Childers Aluminum Weatherproof Jacketing. You can write for a free sample without obligation.

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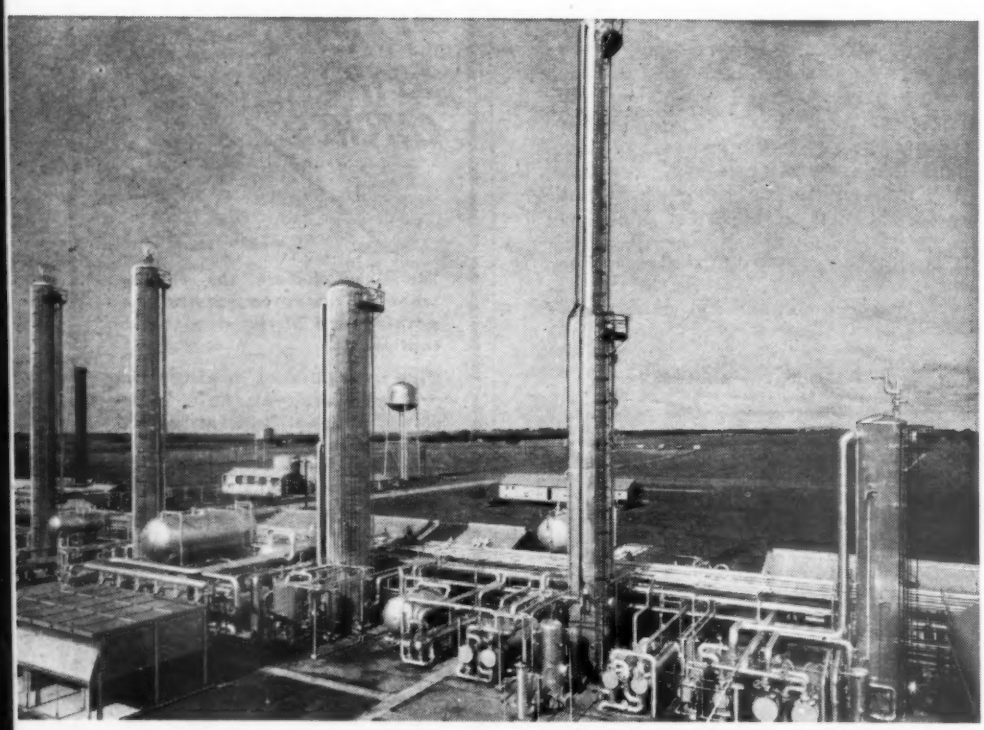
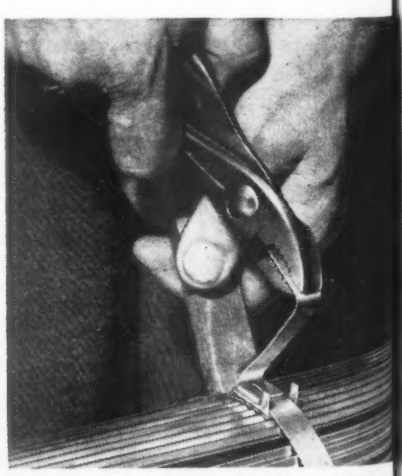


Weather, wind and corrosive gases are not going to attack the insulation of this new plains-country gasoline plant. The insulation is protected by long-lasting aluminum: Childers Aluminum Weatherproof Jacketing. The management expects this low-cost jacketing to hold insulation maintenance costs to a minimum. Other advantages are that the jacketing went on quick and easy during construction; it required no special tools or skill — no shop forming or cutting. It can be taken off and re-used if lines are moved. Aluminum saves on painting and the tough 3S alloy used for Childers Jacketing should stand up for years even in highly corrosive industrial atmospheres. Check the advantages of this jacketing for your own plant.



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Aramco Plans for 1953

Production through the fifth central gas-oil separator plant in Ghawar field was begun early in January of this year. The sixth Ghawar separator plant is scheduled for construction during the year. A 150,000,000 cu ft per day gas injection plant for pressure maintenance of the Abqaiq field is under construction and will be completed late in 1953.

At the refinery, a topping plant with capacity for charging 22,000 bbl daily and a catalytic polymerization unit are expected to be on stream before the end of the year.

Crude runs to stills last year were essentially at maximum rates throughout the year, totaling 62,204,161 bbl, an average of 169,957 bbl daily. In August charge rates approached 200,000 bbl daily; this capacity is expected to be realized or exceeded in 1953.

ties, building of roads, electrification of towns, improvement of water supply, establishment of schools, hospitals, and experimental farms, town planning and training of independent Arab contractors. The company provides extensive training and welfare facilities for Saudi Arabian employees, some of whom are beginning to hold positions of increasing responsibility in the organization.

For every dollar spent on new oil facilities Aramco expends an additional dollar and seven cents on supporting community facilities. The latter includes 27 cents for American housing and related community facilities, 19 cents for Arab housing and ancillary conveniences, including hospitals, schools and recreation, 28 cents for all types of industrial supporting facilities and 33 cents for equipment of all kinds. In the United States, Canada, and Western Europe most of these supporting facilities are provided by private enterprise separate from the oil industry, or by the central or local governments. In Saudi Arabia, as in Venezuela, Aramco has had to provide all of them.

Slowly the administrative machinery, which the use of the country's newly-found oil wealth imposes, is being evolved, but geography, distance, and natural inertia are always formidable obstacles. The establishment of suitable exchange rates led to the creation in 1952 of the non-profit Saudi Arab Monetary Agency, with a board of local directors and an American as its Governor and chief executive officer. It also serves as a central body for budgetary control, for issuing and controlling currency and performing many of the functions of a modern treasury, including provision of financial and economic information to the Government to aid it in formulating and executing its financial and economic policies. It is intended also that the agency should hold reserves both to strengthen the currency, and also as a security against any future decline in oil income. * * *

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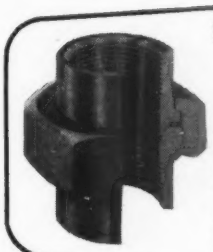

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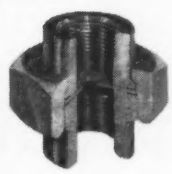

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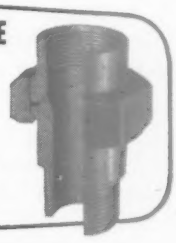

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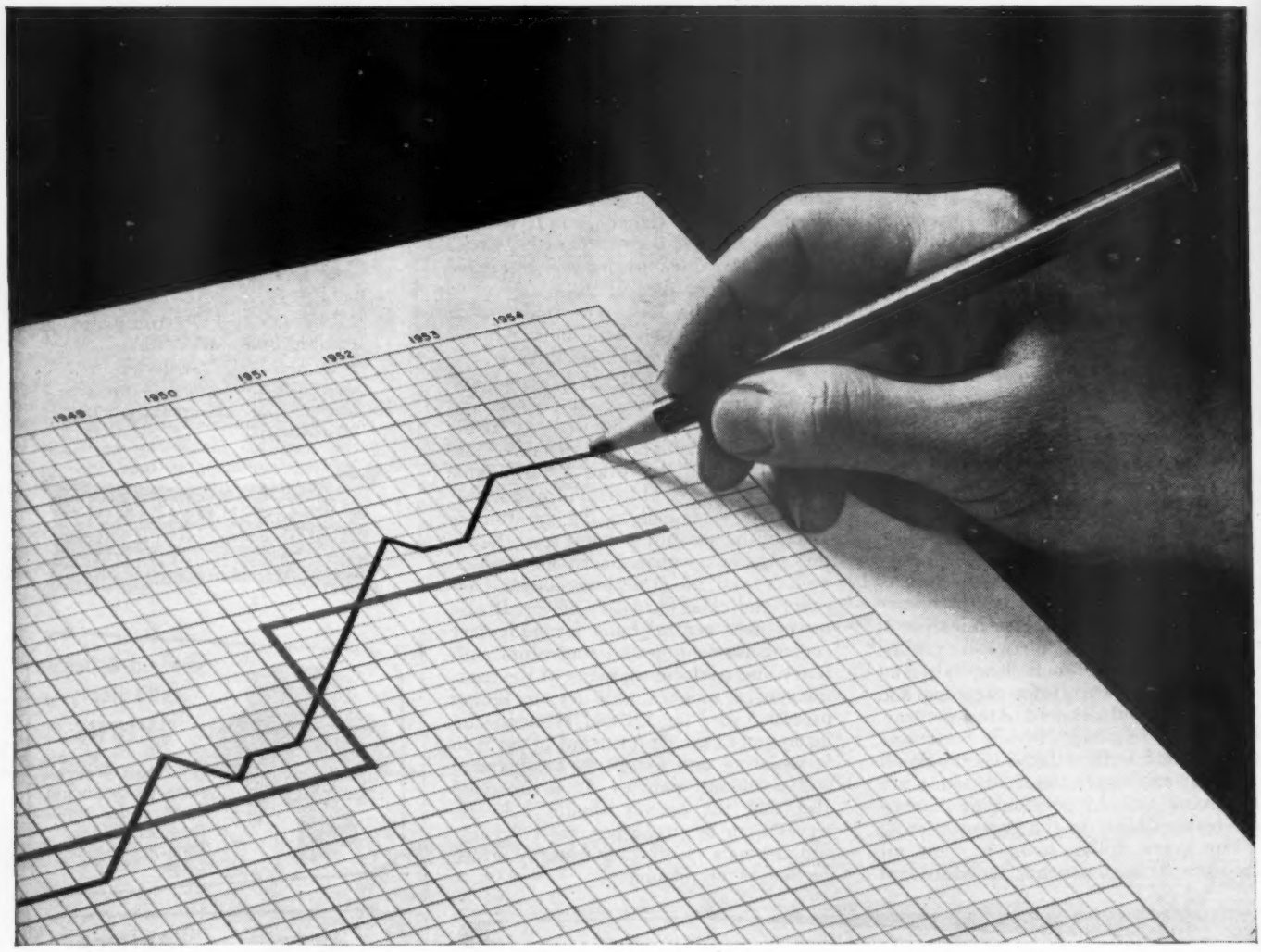

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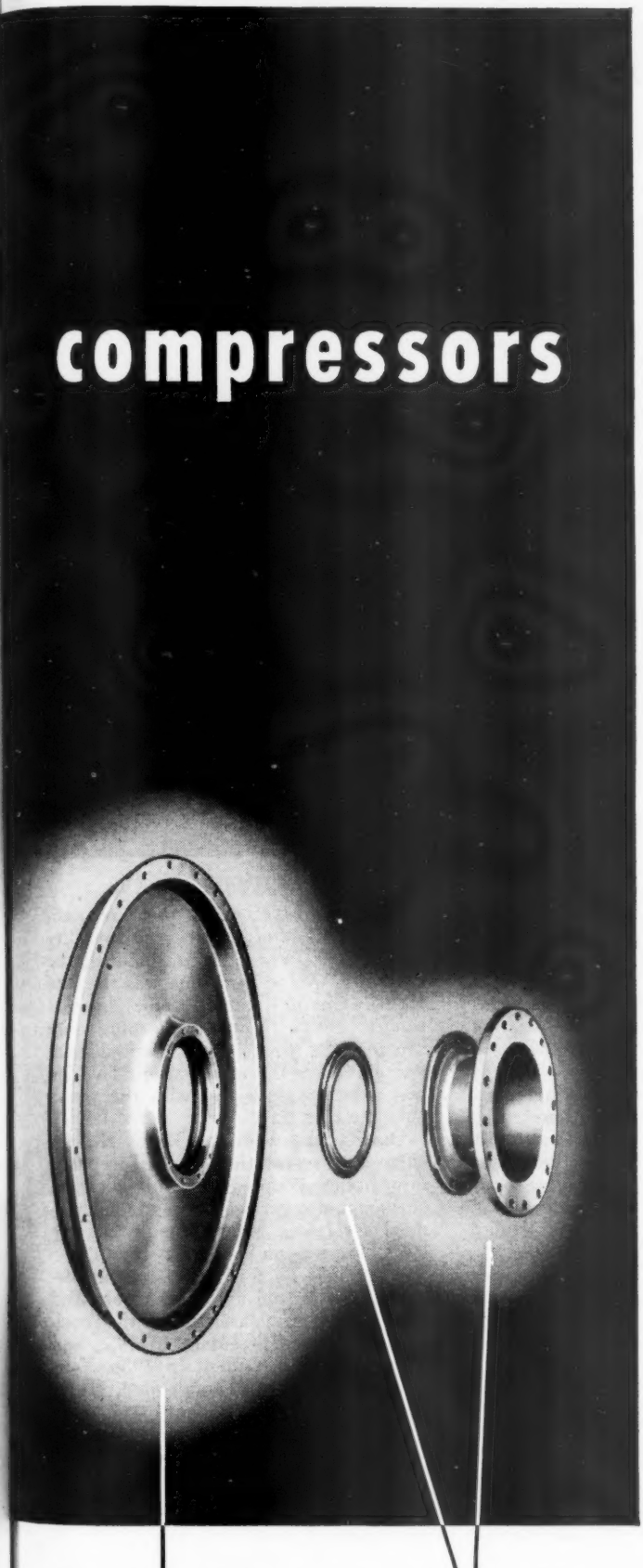

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Petroleum Profile

THERE probably isn't a person in the nation about whom more words have been written for newspapers, magazines, and personal tributes, than Dechard A. Hulcy, president of the Lone Star Gas Company.

Writers around the country have tried their hand at capturing phrases and composing adjective-filled sentences to describe the tremendous personality and ability of this man. His great human warmth and naturalness and his business genius are a pleasant theme for reporters, who admire and respect him.

Never is he evasive with a "no comment" answer for them but instead, often takes them into his confidence and none has ever betrayed him. As one veteran reporter puts it, "In all my dealings with important people, Hulcy is the nicest guy I ever met."

Many men have personal warmth and the easy naturalness that are components of the man Hulcy. Many have the genius for getting things done, big things on which their communities, their companies, and their natiton are built. Too few have that rare combination of both which is the foundational structure of the man who at one time was serving simultaneously as president of his company, president of the American Gas Association, and president of the Chamber of Commerce of the U. S.

Perhaps the simplest yet most all-inclusive statement made about him was when 600 of his Dallas friends and fellow-citizens turned out for a Deck Hulcy Appreciation Dinner following his election as U. S. Chamber president in 1951. "He is the easiest person in the world to say something nice about and still be telling the truth," said the speaker, adding, "The greatest tribute to any man is that he is loved by other men."

The statement's full meaning was borne out the same evening when an employee presented Deck Hulcy with a leather bound book in which the names of 6000 Lone Star employees had been personally signed to a glowing tribute to their chief executive.

"In this book," said the employee spokesman, "you can find out how we feel about you."

In replying, Hulcy added, "I think I know they love me because I love them."

Although Deck Hulcy has received two honorary degrees from colleges in his home state, he didn't have the opportunity in his youth to acquire that much formal education. He started his business career at 15 working as a messenger boy for a railroad.

A Washington correspondent described his as "the true story of how a poor boy can start at the very bottom in the American scale of things and rise to the top." Another referred to him as "the Abe Lincoln of the gas industry."

D. A. HULCY

President
Lone Star Gas
Company

Born on a share-cropping East Texas farm he rose to become the head of his company at the age of 47 and the Number 1 gas man of the nation 10 years later. He completed his tenure as president of the American Gas Association a few months after his election as president of the U. S. Chamber.

Perhaps one of the greatest humanizing forces of this man's life were his humble beginning and his later struggle to give his growing family the better things of life.

Long a civic worker and leader in his community and his church, Deck Hulcy urges his employees to do likewise.

"If you live in a community, you owe more than just taxes to the welfare of that community," is a belief that he practices. And as a result of his example, Lone Star employees throughout the 150,000 square miles of its operating territory are civic minded.

"We take for granted that we possess the greatest opportunities and freedom of any peoples in the world and fail to grasp the fact that these opportunities and freedoms carry with them vital responsibilities," he has said. "If we do not assume these responsibilities, we run the grave risk of losing the privileges which have given us blessings never given to any other people in history."

Deck Hulcy early realized his opportunities, and his responsibilities. Starting with the company in 1920 as an accounting clerk after moving his wife and four children to Dallas from Palestine, Texas, he received quick recognition for his thoroughness and ability with figures. When the president of the company, who at that time was the late L. B. Denning, wanted some detailed reports for a Monday morning rate hearing, the young clerk worked Sunday gathering the information. Then he was asked to go along with the president the next day.

During the hearing, Deck Hulcy's clear-cut presentation of the prepared information coupled with his pleasing and magnetic personality made councilment ask later, "Who is that young fellow?" He was on his way to the top.

After that he was given special statistical duties and a private office. And in 1929 he became assistant to the president, then vice president in 1935 and executive vice president in 1936. Four years later, when Denning died, Hulcy succeeded him as president.

The period since that time has marked the greatest expansion in the company's history. The company has put a strong shoulder to the wheel for industrial development within its territory, pushed ever forward in its search for new reserves and taken the lead in plant construction to reopen shut-in fields which had no provisions for gas conservation.

When Hulcy received an honorary Doctorate of Laws degree from Texas Wesleyan college it was truly said, "(he is) a shining example of American genius and opportunity overcoming lack of early education by an imperial will to achieve and to grow."

XUM

Presenting—

SOUTH DAKOTA — GEOLOGY AND STRATIGRAPHY

Still in the dry hole column, South Dakota is moving ahead in its attempt to become the twenty-eighth oil producing state. Containing the southern portion of the Williston Basin, called the Lemmon Syncline, there are some 19,000 sq. miles which show promise for future petroleum production. Sedimentation in this area may exceed 9400 ft in thickness. Sporadic drilling has been done since the end of World War I with shows of oil reported in some wells but without the development of commercial production. Now the state is again active, with some twelve million acres under lease, and several wildcats being drilled. In view of the large sedimentary thickness and the gradually accumulated structural knowledge, the state may soon be added to the list of those producing oil.

EXPERIMENTAL BASIS FOR NEUTRON LOGGING EVALUATION

As a definite relation exists between hydrogen concentration in a formation and the liquid-filled porosity of the formation, a measure of this hydrogen concentration should be an indication of the porosity. This new neutron logging device makes use of this principal. When atoms of hydrogen, silicon, chlorine, etc., are bombarded with neutrons, they decrease the velocity of these nutrons until they finally capture them. This capture is accompanied by the emission of energetic gamma rays called "gamma rays of capture." Mass of the hydrogen atom being the approximate equal of that of the neutrons they rapidly loose energy and are captured close to their source if the hydrogen concentration is high. The "gamma rays of capture" thus released are too far from the gamma counter to be detected hence the machine "sees" relatively few gamma rays where the hydrogen concentration is high as will be found in porous zones containing hydrocarbons. The paper presents the experimental reults obtained and offers a simple empirical method for porosity evaluation.

HYDRAULIC FRACTURING WITH EMULSION

Since 1948, the use of a viscous fluid to rupture and open tight formations has found generally wide acceptance in the oil industry. These fluids are usually of three classes, gelled kerosine, viscous or gelled crudes, and acid-kerosine emulsions. This latter agent has had signal success in some of the West Texas limes and dolomites that had previously responded poorly to the other fluids, and has also been used successfully in the dolomites and dolomitic limestones found in the Hugoton gas field in Western Kansas. A discussion of the techniques employed and the results obtained is presented.

STORY OF A FLOOD

Opened in May of 1945, the Odin field enjoyed rapid development and had produced over two hundred thousand barrels of oil by the end of the following year. Its very rapid decline in productive capacity coupled with the general absence of water production demonstrated the lack of water drive as a producing agency and led to the decision to institute a program of water injection. After consideration of various available injection methods, it was decided that a peripheral injection pattern with the input wells situated around the edges of the field would be most satisfactory. A unitization program was worked out and the pilot flood instituted late in 1949. Success of this pilot operation being evident, full scale injection was begun and the yield from the field was increased from the pre-flood rate of 92 bbl per day to a peak of 1192 bbl. Water flood recovery from the field through May 1953 has been nearly 800,000 bbl, more than twice the primary recovery of 380,000 bbl. and production is still more than 500 bbl per day.

SELECTION AND APPLICATION OF SUCKER ROD PUMPS

An accurate accounting of the money alert operators save, or conversely, the money less astute operators lose through the poor selection and mis-application of sucker rod pumps would be most interesting. This single factor is probably the greatest of the many considerations to be taken in the reduction of lifting costs. As the bore size of the pump directly affects the magnitude of the sucker rod load, it determines the size of the surface equipment required to produce the well, thus controlling a major item of capital investment and influencing the power requirements of the unit throughout the life of the well. The pumps' ability to resist corrosion and undue wear due to adverse well conditions will determine well service requirements and in part well productivity, thus influencing both lifting costs and ultimate recovery to some extent. This complete guide to the selection of subsurface units is commended as a guide and possible key to greater future profits.

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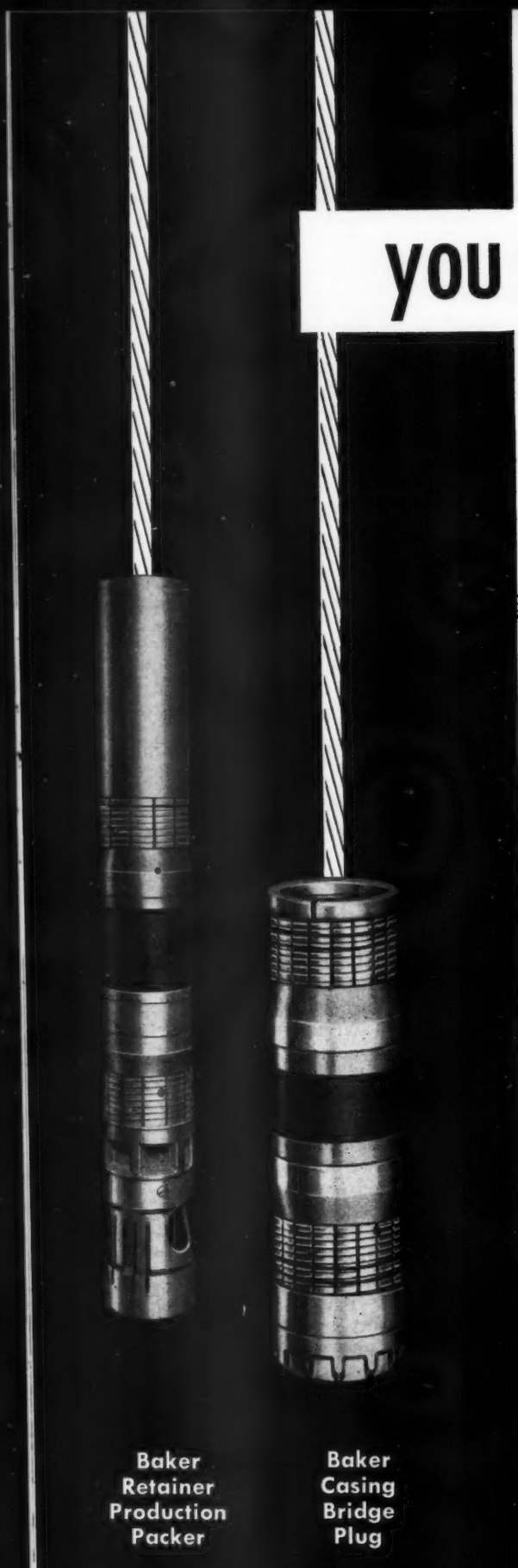

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THE BEST PROOF of these savings is the increased number of wire line setting jobs by oil operators everywhere. For example, out of the total number of Baker Casing Bridge Plugs set during the year 1951, 71% were run on wire lines.

AND REMEMBER that all these *SAVINGS INCREASE* as *WELL DEPTHS INCREASE!* Out of all the Baker Packers set on wire lines during a recent six-month period, over 22% were set at more than 10,000 feet. The saving in round trip time over using tubing or drill pipe is an important item; and even more important is the elimination of wear and tear on tubing when a wire line is employed for setting.

Consider, too how wire line setting helps you to avert premature setting of either device, caused by junk or other debris in the hole. And don't overlook the fact that in many instances both the gun-

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SURFACE FEATURES IN NORTHWEST SOUTH DAKOTA

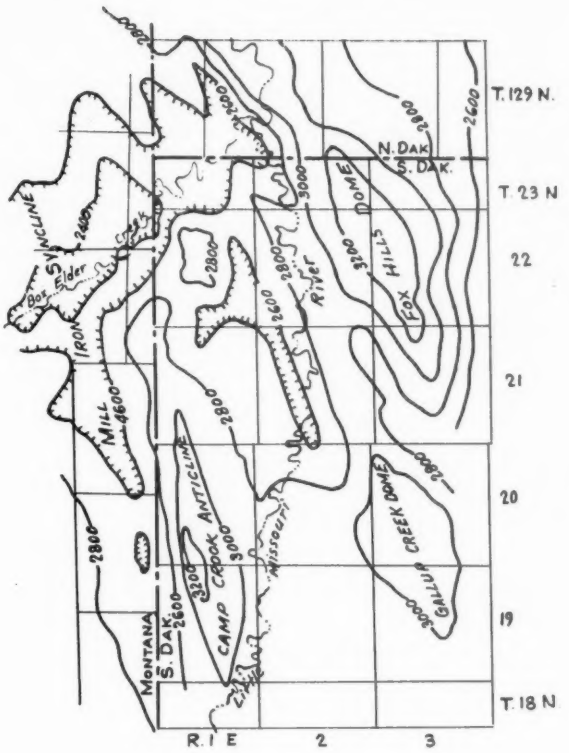

FIG. 1. CONTOURED ON TOP PIERRE FORMATION.
(From U. S. Geological Survey press notice 3762)

South Dakota— Geology and Stratigraphy

Great interest is concentrated in the expectant oil state in the southern curve of the Williston Basin

JAMES L. BROWN

THE Laramide Revolution that elevated the Rocky Mountains also tilted the relatively flat ocean basin that lay in front of them so that it sloped gently eastward. This slope, some 500 miles in width, is the region known as the Great Plains. A composite picture of the surface of the Great Plains in South Dakota would show a rolling topography, surmounted in places by high buttes and locally cut by deep canyons. The boundary between the Great Plains and the eastern Glaciated Plains province in South Dakota is roughly marked by the valley trough of the Missouri River.

The South Dakota portion of the Williston Basin, known as the Lemmon Syncline, consists of approximately 19,000 sq miles, with a maximum sedimentary section exceeding 9400 ft. The trough, which plunges northward into the deeper part of the Basin in North Dakota, is bordered on the west by the Black Hills Uplift and on the east by the Sioux Uplift. The latter has been a fairly stable platform throughout geologic time and is composed of pre-Cambrian sediments. These rocks when buried are covered by a relatively thin mantle of post Cambrian sediments.

To date there has been no commercial production of petroleum within the state of South Dakota. Before discovery of oil in North Dakota, some interest had been shown in the Cretaceous sands because of the successes in Wyoming and Nebraska. Numerous exploratory tests were drilled in the area around the Black Hills, but all were dry. Oil shows were encountered in the Paleozoic sediments in two deep tests drilled by the Shell Oil Company in Corson and Perkins counties and a well now being drilled by the Carter Oil Company in Harding County; a small amount of free oil was recovered on a drill stem test in this latter test, but to date this show has not been evaluated.

During the past several years numerous seismic crews and field parties have been active in the Lemmon Syncline and the State Geological Survey has completed two magnetic surveys in the eastern part of the state. Leasing has kept pace with the exploration activity. In the northwestern counties of the state the recent lease play began in the early part of 1949 and continued until the present time. It is now estimated that over 12,000,000 acres are under lease in South Dakota.

General Surface Geology

Butte and canyon topography occurs in that portion of the state lying west of the Missouri River, and covers the largest area of any single topographic division in South Dakota. All the large streams and the majority of the small ones flow in canyons 200 or more feet in depth and the uniform type of soft bedrock combined with semi-arid climate makes badland areas common.

The Laramide orogeny, which folded the Rocky Mountains, also formed the two major structures of western South Dakota, the Black Hills uplift, and the Lemmon Syncline. The Black Hills uplift included not only the Hills proper but a series of long narrow folds trending northwestward into Montana where the folds join the trend of the Cedar Creek Anticline. East of the Black Hills and south of the Cedar Creek lies the large Lemmon trough which occupies most of western South Dakota between the Black Hills and the Missouri River. The axis of the Syncline plunges northwestward through the City of Lemmon in Perkins County into North Dakota at a rate of 30 to 40 ft per mile. A number of smaller structures are found within the syncline; these were superimposed by slight variations in the stresses attendant upon the general movement. In northwestern South Dakota several sets of superimposed folds have been mapped on this general northwest dip. The Fox Hills Dome, largest of these posi-

EXCLUSIVE

The Author

James L. Brown is a consulting geologist with offices in the Petroleum Building, Bismarck, North Dakota. He is a graduate of the University of Cincinnati and holds BS and MS degrees from that institution. He was an Infantry Captain during the World War II, and was a member of the geological staff of the Shell Oil Company prior to becoming a consultant.

tive structures, appears to be a direct southeastern extension of the Cedar Creek Anticline of Montana and has a surface closure exceeding 200 ft. (See Fig. 1.) Other western structures include the Gallup Creek Dome, the Camp Crook Anticline and the Whitewood Anticline, a northern projection of the Black Hills.

Pleistocene glacial deposits cover much of the state east of the Missouri River and make field mapping difficult. Throughout most of the unglaciated portion of the state numerous small surface features have been mapped and many Reports of Investigations of the South Dakota Geological Survey describe these structures. It is considered problematical whether many of these smaller surface features continue with depth.

Stratigraphy

This brief outline of the stratigraphic section in South Dakota has been compiled from outcrop descriptions and sample examination of well cuttings from tests in the Lemmon syncline. Throughout the Basin, numerous correlations based lithology and stratigraphic relationship have been proposed. In the future when more faunal evidence has been evaluated many of these correlations and names will be changed and revised.

Pre-Cambrian. Granitic types of pre-Cambrian rocks have been encountered in many deeper Lemmon Syncline tests and basic igneous rocks have been found in several wells on the east flank of the Basin. In the Black Hills, igneous rocks and a thick metamorphosed sedimentary section of pre-Cambrian age are exposed on outcrop.

In the central and southeastern part of the state, the basement complex is overlain by the Sioux quartzite, locally called the "Sioux Falls Granite." This sedimentary quartzite is a pink, well-cemented sandstone that crops out in southeastern South Dakota and southwestern Minnesota. The exact age of this unfossiliferous formation has not been determined. It has been shown to rest unconformably below the Deadwood in several exploratory tests and is therefore pre-upper Cambrian. On the basis of lithology, the Sioux quartzite has been correlated with the Baraboo quartzite of Wisconsin, which is believed to be Huronian in age.

Cambrian. The only unit of Cambrian age found in the basin area is the Deadwood formation; several well defined faunal zones indicate an upper Cambrian age. The Deadwood is composed of glauconitic sandstone, shale, and dolomite with a maximum thickness of 450 ft at its type locality in the Black Hills. In outcrop the formation rests on the upturned edges of the pre-Cambrian quartzites and schists.

Very little is known about the formation in subsurface in the Lemmon Syncline because of the lack of deep tests throughout the region. There is some question as to where the top should be called and whether the overlying less glauconitic dolomitic section should be placed in the Ordovician or Cambrian. A number of geologists are restricting the term, Deadwood, to the highly glauconitic basal sandy phase of the section. This problem can be solved only by faunal studies from a series of cored intervals.

Ordovician. In the northern region of the Black Hills uplift approximately 150 ft of Ordovician sediments lie exposed. These rocks have been shown to be middle Ordovician in age and are conformable with both the Englewood (Mississippian) above and the Deadwood (Cambrian) strata below. In ascending order the formations are termed Aladdin sandstone, Ice Box shale, Roughlock siltstone and Whitewood dolomite.

The Aladdin sandstone lies directly on the Deadwood and is 12 to 15 ft thick on outcrop. It is a fairly pure, fine to medium, sub-angular to sub-round quartzose sandstone and is characterized by numerous worm (Scolithus) borings. In the vicinity of Nemo, South Dakota, it changes from a thin pure near shore type of deposit to a thick (50-60) red deltatic type of deposit. On the east side of the Basin near Pierre, South Dakota, the Aladdin disappears, probably due to non-deposition. The formation has been tentatively correlated with the St. Peter sandstone of Chazyan age.

In its type section in the Black Hills, the Ice Box shale consists of 30-35 ft of olive green fissle shale, silty in part, containing phosphatic nodules. In basal few feet are numerous sand grains, reworked from the underlying Aladdin sandstone. In the South Dakota subsurface, this formation assumes a thickness that exceeds 150 ft.

The Roughlock siltstone has a thickness of about 30 ft and varies from an argillaceous siltstone to a very pure quartzose siltstone; in the upper few feet the siltstone often grades to a very fine sandstone. Contact with the Whitewood above is gradational and the unit has previously been designated the "transition zone." When traced northward and eastward into the subsurface it undergoes a facies change and is represented by olive-green silty shale with thin streaks of sand. The Roughlock, Ice Box, and Aladdin have been tentatively correlated as age equivalents to the Winnipeg formation of North Dakota and Manitoba.

The Whitewood dolomite consists of a maximum of 60 ft of buff to tan dolomite at its type section. The upper unit of the formation is a massively bedded dolomite and in outcrop contains a good Cephalopod fauna. On the basis of the Cephalopods, Flower (1952) has placed the age of the rocks as Trenton; this age relationship would make the formation correlative to a portion of the Red River formation of North Dakota and Manitoba. When traced from its type locality in the Black Hills into northwestern South Dakota, the Whitewood thickens to a maximum of 700 ft and assumes the characteristics of the Red River formation of North Dakota. The subsurface formation has been described as a dolomite light cream to tan in color, micro to medium crystalline, with slight to fair small vugular porosity.

Overlying the Red River and confined to the subsurface in South Dakota is the Stony Mountain shale. This formation has a very consistent lithology and thickness in the deeper portions of the Basin and is considered an excellent marker; its maximum thickness is 120 ft. The Stony Mountain varies from a dolomitic, green-gray, black mottled shale, to an argillaceous light gray limestone with black fossil fragments. These fossil fragments may indicate that the sea at the time of deposition, was very shallow with the bottom above wave base. The eastern limit of the Stony Mountain is probably controlled by post-Silurian erosion, and the southern limit by non-deposition.

The Gunton formation, overlying the Stony Mountain shale in the northwestern corner of the state, can be recognized as a distinct formation throughout the Basin. It has been described by Baillie in Manitoba outcrop as consisting of red and gray silty dolomites and red shales which grade upward into a highly arenaceous dolomite containing up to 25 per cent of quartz grains. The contact of the Ordovician and Silurian is placed at the top of this prominent sandy zone. This division is not based on direct fossil evidence but rather on a lithology change. Fossil evidence from outcrop and core studies suggests an uppermost Ordovician age for the Stony Mountain-Gunton sequence.

Silurian (Interlake Group). The Silurian type section in the Williston Basin is situated in the Interlake region of southern Manitoba. In outcrop the Silurian may be divided into five separate lithologic units, but so far it has been impossible to delimit them in subsurface. Therefore, the general term, Interlake group, is considered practicable for all Silurian sediments in South Dakota. The group consists of a thick dolomite sequence with thin stringers of limestones and variegated shales and reaches a maximum thickness of approximately 400 ft in the Lemmon Syncline. Fossil evidence in the Manitoba outcrop indicates an Alexandrian and Niogaran age.

The considerable thickness, pureness,

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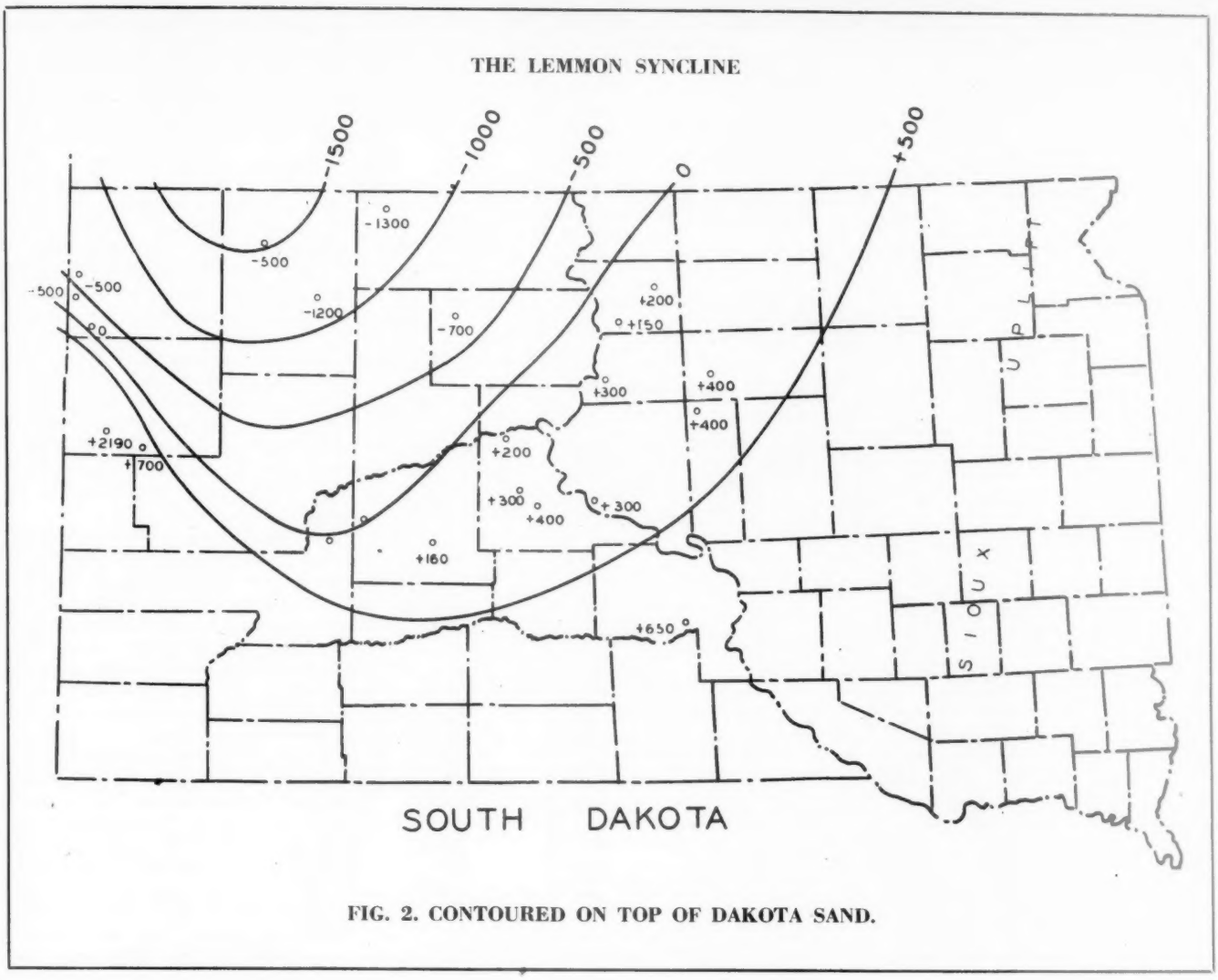

FIG. 2. CONTOURED ON TOP OF DAKOTA SAND.

and similar constitution of the Silurian carbonate deposits suggest a long continuation of uniform conditions. The Silurian sea seems to have been epinertic; disconnected basins with respect to the land, very low land, or land directly underlain by carbonates would account for the absence of detrital material.

Rocks of the Interlake group are restricted to the deeper portion of the Lemmon Syncline. On the east, Silurian sediments have been removed by post-Silurian erosion; the southern limit seems to be controlled by non-deposition.

Devonian. Devonian sediments are restricted to the northwestern portion of the state but may exist as a wedge edge in central South Dakota on the eastern side of the Lemmon Syncline. The Devonian when fully developed is readily distinguished from the Silurian by a basal clastic zone which separates the two carbonate sections. If this basal unit (Ashern) is not present it is often difficult to sub-divide the periods on basis of lithology.

In general the Devonian is a series of alternating limestones and dolomites with traces of silt and some scattered free floating sand grains. The basal unit, Ashern, when developed is a light cream to red argillaceous dolomite, with numerous sand streaks. In some cases the basal portion of the formation may be a well developed sandstone.

The carbonate section above the Ashern is similar in lithology to the upper Devonian in North Dakota; however, this intreval will have to be cored, and fossil determination made before definite age relationships can be established. The red beds and clastics occuring in the basal unit may indicate a reworked soil horizon. After inundation the carbonates were laid down under relatively stable tectonic conditions.

Mississippian. Mississippian rocks are the most widespread Paleozoic sediments in South Dakota. Their present subsurface distribution is limited on the east and southeast by pre-Pennsylvanian erosion, with outcrops restricted to the Black Hills.

The Englewood formation, basal unit of the Mississippian in South Dakota, is a 60-ft pink to buff limestone becoming quite shaly at the base. Tracing the formation into the Lemmon Syncline subsurface, its lithology changes to a sandy, dolomitic red and green shale.

The one other Mississippian formation exposed in the Black Hills is the Pahasapa formation. On outcrop it consists of up to 620 ft of medium crystalline, buff to light gray limestone, in part dolomitic. It lies conformably on the Englewood but is unconformable with the overlying Minnelusa formation. Fossils are fairly common in the Pahasapa and indicate a Kinderhook-Osage age. The Pahasapa can be traced into the subsurface and is found to occupy the same stratigraphic position as a part of the Madison group of North Dakota. Throughout most of South Dakota it is difficult to recognize individual Madison formations, but in the northwestern part of the state subdivision is possible. Above the Englewood shale section, the dark shaly limestones of the Lodgepole formation can be found. These grade into thin cherty limestones with dark shale interbeds. The Lodgepole formation in northwestern South Dakota reaches a maximum thickness of approximately 500 ft.

The Mission Canyon formation of the Madison group is also present in the subsurface. It is a thick carbonate unit composed of a finely crystalline limestone with coarse crinoidal debris, interbedded with units of dolomite that become more prominent and porous towards the top. A maximum thickness of 700 ft has been encountered in northwestern South Dakota. The upper unit of this formation is the most important productive zone in North Dakota. The

TABLE 1. Generalized South Dakota correlation chart.

Era	Period	Epoch	Formation	Max. thickness	Description
	Quaternary		Glacial Drift	400	Covers eastern half of state.
Cenozoic	Tertiary	Miocene	Arikaree	250	Hard gray sandstone and volcanic ash.
		Oligocene	White River	1000	Soft, light colored clay and siltstone.
		Paleocene	Fort Union	900	Sandstone and shale, with numerous lignite beds.
			Cannonball-Ludlow	300	Shale and sand, with some lignite.
Mesozoic	Cretaceous	Upper	Hell Creek	600	Yellow-brown shale, silt and sand ("Somber Beds").
			Fox Hills	200	Buff to gray-white marine sandstone.
			Pierre	1500	Gray shale with siderite concretions; some bentonite.
			Niobrara	225	Calcareous gray speckled shale ("First White Specks")
			Carlile	800	Dark gray shale with siderite concretions.
			Greenhorn	80	Fossiliferous limestone and gray, limy speckled shale. ("Second White Specks")
			Belle Fourche	850	Dark gray shale with siderite concretions.
			Mowry	250	Silver gray siliceous shale.
		Lower	Newcastle	60	Sand and shaly sandstone.
			Skull Creek	300	Dark gray shale.
			Dakota	200	Fine sandstone and gray shale.
			Fuson	190	Gray to variegated shale, often containing manganosiderite pellets.
			Lakota	485	Coarse sandstone and gray shale.
	Jurassic	Upper	Morrison	220	Green to variegated shale.
		Middle	Sundance	550	Fine glauconitic sandstone and green shale; some carbonates, red shale, and evaporites.
	Triassic		Spearfish	700	Red sandstone and shale with some gypsum.
Paleozoic	Permian		Minnekahta	50	Gray-pink, thin-bedded limestone.
			Opeche	130	Red silty shale.
	Pennsylvanian		Minnelusa	850	Pink-red sandstone and dolomite.
	Mississippian	Osage	Pahasapa	800	Light colored fossiliferous limestone; some oolitic beds; some dolomite.
		Kinderhook	Englewood	60	Pink to purple dolomitic shale and dolomitic limestone.
	Devonian			300	Limestone and dolomite; (only in northwest).
	Silurian			350	Light colored carbonates; (only in northwest).
	Ordovician		Whitewood	700	Limestone and dolomite (60 feet in Black Hills and thickens rapidly towards north).
		Mohawkian	Roughlock	50	Shaly silstone ("Transition zone").
			Ice Box	150	Green shale ("Black River shale").
		Chazyan	Aladdin	100	Coarse sandstone ("St. Peter sandstone").
	Cambrian	Upper	Deadwood	350	Glauconitic sandstone, dolomite, and green shale.
	Pre-Cambrian				Granite, quartzite, basic igneous rock.

Lodgepole and Mission Canyon are separated on the basis of lithology in subsurface, but no division has yet been positively made where the equivalent Pahasapa limestone outcrops in the Black Hills.

The Charles formation, upper most member of the Madison group, is found in subsurface in the northwest portion of South Dakota. It is composed of massive interbedded limestones, dolomites, and anhydrites. In the deeper part of the syncline there are three well defined sedimentation cycles consisting of fossiliferous limestones, crystalline, and dense dolomites, and anhydrites. The base of the Charles formation is placed at the base of the last massive anhydrite which is usually steel gray in color.

No upper Mississippian (Chester) beds outcrop in the region around the Black Hills, but beds of this age are believed to be present in subsurface in the northwestern part of the state. As yet definite correlations cannot be made on lithology alone due to rapid lateral and vertical change of facies. Units probably correlative with the Big Snowy group of central Montana are occasionally divisable into Kibbey sandstone, Otter shale, and Heath shale; in most cases, however, individual formations of the group cannot be recognized. Thickness of the Big Snowy group seldom exceeds 300 ft; sedimentation on the east seems to be lacking because of nondeposition.

Pennsylvanian. The term Minnelusa is now applied to all sediments occuring between the Pahasapa (Mississippian) limestone and the Opeche (Permian) shale in the Black Hills. The formational thickness varies from 1300 ft in the extreme southwestern corner of the state to 300 ft in the northwestern corner; the Minnelusa is composed of sandstone, shale, dolomite, limestone, and evaporites. It extends eastward into the subsurface, thins rapidly by overlap on the pre-Cambrian, and is missing a short distance east of the Missouri River. The Minnelusa of South Dakota is Pennsylvanian in age and fossils are relatively abundant; however, a comparison of faunal lists leads to contradictory conclusions and it is not known how many epochs of Pennsylvanian age are present.

Permian. This Opeche formation, at its type section in the Black Hills, consists of 90 to 110 ft of brick red siltstone and shale which lies unconformably on the Minnelusa. There are no fossils in the unit and correlations are based on lithology and its position in the stratigraphic column; it is considered to be Permian in age.

Approximately 40 ft of thin-bedded alternating limestones and dolomites constitute the Minnekahta formation. The unit is gray to purple in color and on outcrop has a varved appearance. Fossils are comparatively rare and poorly preserved. Throughout western South Dakota the color, lithology and thickness are fairly consistent and the Minnekahta is recognized as a good marker bed. It has been tentatively correlated with the Permian of Wyoming.

Triassic. Spearfish beds of Triassic (?) age crop out in a continuous belt around the Black Hills uplift and extend in subsurface eastward to the Missouri River. They have a maximum thickness of 350 ft and consist of fine to coarse sandstones and red shales. The formation is unfossiliferous but stratigraphic correlation with equivalent beds in Wyoming indicates that the Spearfish is Permo-Triassic in age.

Jurassic. The Jurassic period is represented in South Dakota by the Sundance and the Morrison formations. The Sundance is a thick series of alternating sandstones and shales of marine origin. The type section is in the Black Hills and the formation has a maximum thickness exceeding 300 ft. In subsurface it extends northwestward into the deeper areas of the Basin, and eastward past the Missouri River.

The Morrison formation is composed of green and gray non-marine shales with thin interbeds of sandstone; the maximum thickness exceeds 200 ft. The Morrison is found in subsurface throughout the deeper part of the Basin and as far east as the Missouri River.

Cretaceous. The lower Cretaceous rocks in South Dakota consist of approximately 1100 ft of marine and nonmarine formations called, in ascending order, Lakota, Fuson, Dakota, Skull Creek, and Newcastle.

The lowermost unit, the Lakota, is composed of up to 485 ft of massive sandstone and interbedded gray shale. The sand is fine to medium with local conglomeratic streaks and appears to be non-marine in origin.

The Fuson formation consists of up to 190 ft of variegated clays and sand-

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stones. The basal zone is usually a buff clay containing numerous siderite pellets; this particular horizon can be traced east of the Missouri River. Fossil plants found within formation are considered to be lower Cretaceous in age.

The Dakota (Fall River) formation is a fine grained sandstone with numerous thin streaks of gray shale. It has a maximum thickness of 200 ft and appears to be of marine origin.

A series of dark gray marine shales having an average subsurface thickness of about 250 ft constitute the next higher Skull Creek formation. Its age has been determined as lower Cretaceous on the basis of micro fossils.

Cross bedded sandstones, sandy shales, light gray shales with local sand stringers, and beds of lignite make up the Newcastle formation. It has a thickness of from 40 to 60 ft and is, in part, marine. The formation is generally interpreted as a closing phase of Lower Cretaceous deposition.

Upper Cretaceous sediments include, in ascending order, the Mowry, Belle Fourche, Greenhorn, Carlile, Niobrara, Pierre, Fox Hills, and Hell Creek formations.

The basal upper Cretaceous unit, the Mowry shale, is composed of hard siliceous claystone with interbedded streaks of bentonite. The formation reaches a thickness of about 250 ft.

The Belle Fourche formation is a dark gray marine shale containing numerous concretions of siderite and reaches a maximum thickness of 850 ft.

The Greenhorn formation, a widespread marker bed, consists of up to 80 ft of calcareous shales and limestones. Marine fossils are present throughout the formation. Overlying the Greenhorn is the Carlile shale, a marine formation consisting of dark gray shales with numerous siderite concretions, and local thin beds of sandstone. Its maximum thickness is about 800 ft.

The next higher Niobrara formation is composed of up to 200 ft of calcareous shale and marl with many thin beds of bentonite. The formation is light gray to brown in color and is characterized by its white speckled appearance.

The Pierre formation consists of a maximum of 1500 ft of marine sediments. The basal unit is composed of 600 ft of gray mudstone with numerous ferruginous concretions. In the middle and upper units several local thick sandstones are sometimes found. The upper unit is a series of medium to dark gray shales. Bentonite beds are common throughout the Pierre.

The Fox Hills sandstone consists of a sandy shale grading upward into a massive gray sandstone. The formation reaches a thickness of some 150 ft.

The uppermost Cretaceous, the Hell Creek formation, is an extremely variable series of non-marine sediments. The formation is composed of sandstones and mudstones with numerous log-like ferruginous concretions. It reaches a maximum thickness of about 500 ft.

Oil History: Past and Future

In the years following World War I, oil enthusiasm was quite high in South Dakota and many areas were leased. Several test wells were drilled on geological information and surface highs mapped by the State Geological Survey. In the early 1920's the first deep well (the Standing Butte test) was drilled on the east side of the Lemmon trough; its total depth was 3508 ft in the Madison formation. About the same time several other tests were drilled but were not carried deep enough to encounter the major potential oil and gas zones. In 1940 Carter Oil Company drilled two holes near the Missouri River; both were drilled as stratigraphic tests and bottomed in granite.

During the 1939-40 season the Camp Crook anticline was drilled by the States Royalty Petroleum Company. This test revealed several Paleozoic formations that were absent in the Black Hills and brought up the possibility of pinchouts in the Mississippian, Silurian, and Devonian. A slight show of oil was reported in the "St. Peter" sandstone, but it was not considered good enough for commercial production. In 1943 Carter and Northern Ordnance drilled another well in the same general area. This was also a failure. Another test was drilled by the same companies approximately 18 miles southeast on another surface feature. It was carried a depth of 7038 ft with no shows reported.

During 1944-45, the Phillips Oil Company did geophysical work on the east side and as a result of this information drilled a series of three tests to the basement complex. In 1945-46 Amerada Petroleum Company drilled a series of four tests south of the Black Hills; slight oil shows were reported in these wells. In the same general region Woodward Oil drilled 11 shallow tests and secured several small gas wells.

The most recent series of tests was drilled by Shell Oil Company in the northwestern part of the state. The tests located on seismic highs, were all taken to granite, encountered at depths greater than 9000 ft. Numerous light oil stains were encountered in the Paleozoic, but none of the wells produced oil in commercial quantities.

At the present time several significant rank wildcat wells are being drilled and a number of additional tests are planned. The current drilling Carter No. 1 Hendricks, situated in Harding County on the south end of the Fox Hills Dome, recovered a small amount of free oil on drill stem test in the Red River (Ordovician) formation. This is considered highly significant and further testing of this well is being watched with great interest.

In view of the favorable stratigraphic section, known surface structures, and accumulated seismic information, the outlook for South Dakota as an oil producing state appears bright. This year, 1953, should prove to be the biggest exploratory year in the state's history, and commercial production may well become a reality in the near future.

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Montana Test Well Scheduled by Flank Oil

New British Dominion Oil Company, Ltd., has announced that its wholly-owned subsidiary, Flank Oil Company of Montana, has entered into a contract with Amerada Petroleum Corporation for the drilling of a deep test well in the Absher area of Musselshell County, Montana. The test well is considered of great importance to the general area because of its location on a structure in the Bull Mountain Syncline which is generally considered to be the probable northwest extension of the prolific Powder River Basin.

Flank company will drill a test well to evaluate all formations down to and including the Mission Canyon or a total depth of 8200 ft or commercial production, whichever shall occur first.

Regent Drilling Company is the contractor for the drilling of the well, Flank Oil Cartwright No. 1.

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FIG. 1. VISCOUS fracture emulsion at left, and broken emulsion at right.

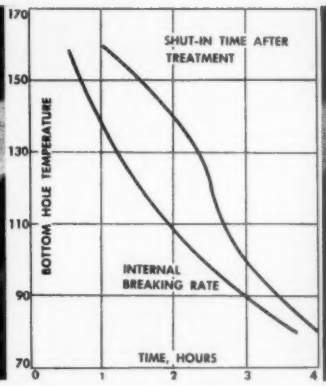

FIG. 2. BREAKING characteristics of emulsion.

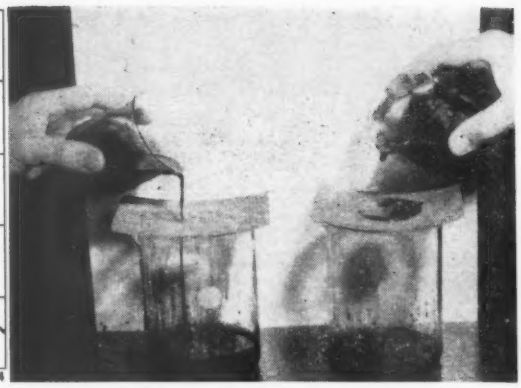

FIG. 3. HEAVY petroleum residue before, right, and after solution with emulsion.

Hydraulic Fracturing with Emulsion Stimulates Production

Success with modified acid-kerosine emulsion fluid especially good in limestone and dolomite

M. A. WHITFIELD and C. H. HUTCHINS

FORMATION fracturing by hydraulic processes is a widely accepted technique for the stimulation of oil and gas production. A hydraulic fracturing process may be defined as an operation whereby a viscous fluid containing sand is pumped against reservoir rock to force a separation of the structure by means of pressure. After being injected into natural or induced rock fractures the viscous fluid thins, and sand is deposited to maintain the openings. Although there is not yet a mathematically practical method of calculating the production influence of fractures in reservoir flow systems, Muskat and others have shown that it is possible to obtain an approximation of their significance.[1] Field applications of various fracturing processes have proved the production benefits derived from such treatments in thousands of wells. The conclusions of a research group in a recent paper[2] were that hydraulic fracturing may accomplish one or more of three effects in saturated rock:

1. Increase the drainage areas of the flow system.
2. Break through permeability blocks in the immediate vicinity of the well bore.
3. Break through dense or impermeable rock into a permeable saturated zone.

Hydraulic fracturing of reservoir rock was developed as a commercially feasible process in 1948, and considerable progress has been made through extensive field experience and research. At present there are three commonly used fracturing fluids all incorporating a graded Ottawa sand. These are: Gelled kerosines; viscous or gelled oils, and acid-kerosine emulsions. Fracture treatments have been made in almost every known type of productive rock. Sandstones in general have yielded the most consistently favorable results. In the past, fracture treatments in limestone and dolomite gave erratic results and were frequently no more effective than were treatments with hydrochloric acid. Recently, however, a modified type of acid-kerosine emulsion fracture fluid has been used to stimulate production in more than 100 wells in the Permian Basin, North Texas, and Western Kansas areas. A description of this type of emulsion and its properties is presented, followed by a summary of the treatment results.

Composition and Properties Of Fracture Liquid

This improved acid-kerosine emulsion is composed of 15 per cent hydrochloric acid with an inhibitor, a commercial grade of kerosine, an emulsifying agent, and a de-emulsifying chemical. The emulsifying agent, as its name implies, acts to form a viscous water-in-oil emulsion. The de-emulsifying chemical serves to thin the emulsion after a controlled period of time, and in addition it reduces the surface tension of the broken fracture fluid. This prevents occurrence of heavy sludges that could impair permeability of the reservoir rock flow system. These properties also assist in a rapid clean-up of the formation and are particularly desirable in low pressure pay zones. The proportion of acid to kerosine in the mixture is three to one with the other chemicals added in relatively small quantities. This mixture is mechanically agitated until a white fluid of approximately 5000 centipoises viscosity (Hoeppler Viscosimeter) is formed. The viscosity and gel strength of the emulsion are adequate to support and transport one-half to four pounds of 20-35 mesh Ottawa sand. (Fig. 1) With one-half pound of sand suspended per gallon of emulsion, the specific gravity is the same as that of water. Time required for emulsion to revert to a consistency comparable with kerosine is dependent on the temperature. This time interval is 2.5 hours at 110 F when in contact with dolomite. (Fig. 2) Contact with a calcareous formation is not necessary to break the emulsion. This property makes the emulsion adaptable for fracture application in sand zones.

Fracture fluid is a water-in-oil type emulsion, therefore, it is completely soluble in formation oil. Viscosity of the emulsion rapidly decreases as it is diluted with crude oil. (Table 1) Heavy petroleum residues can be taken into solution by the oil soluble emulsion,

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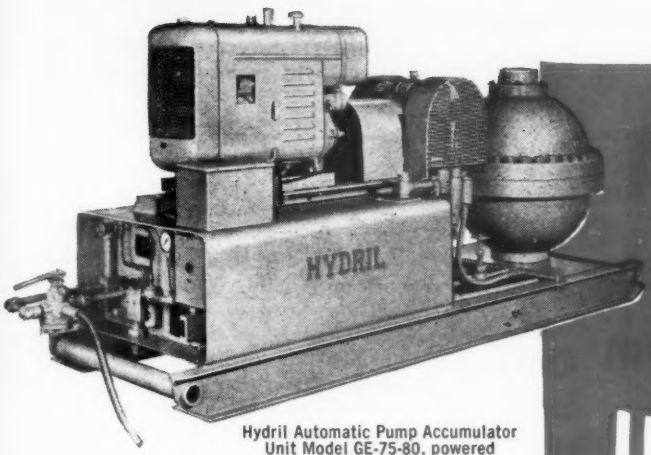

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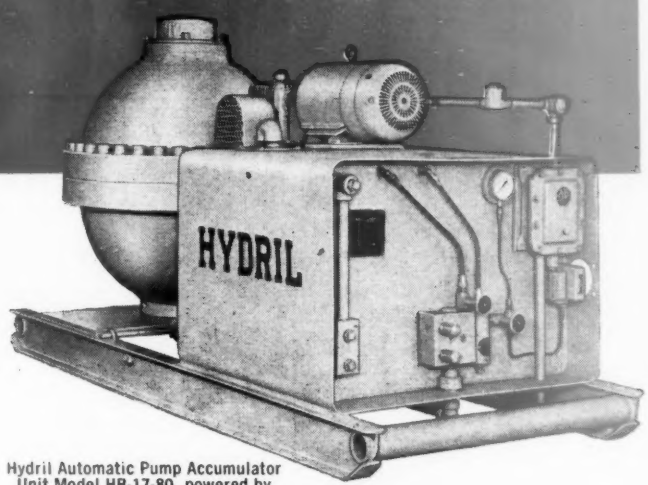

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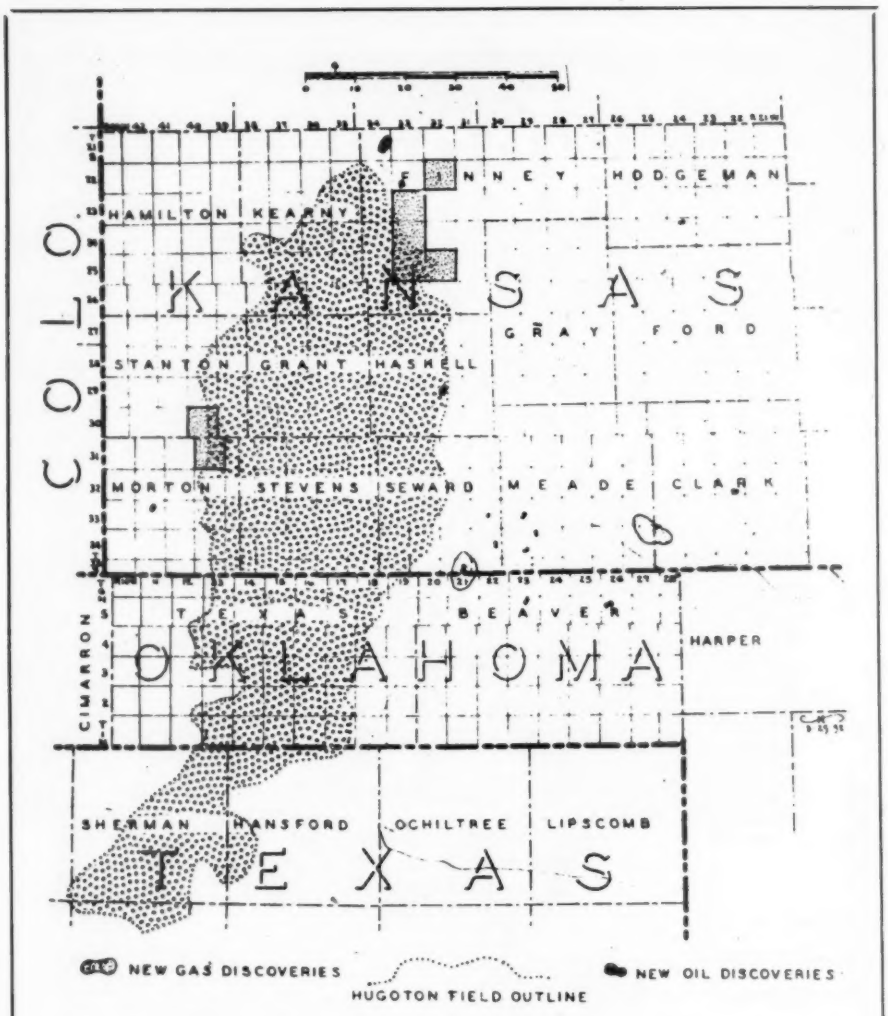

FIG. 4. HUGOTON FIELD of Kansas, Oklahoma, and Texas.

which makes the emulsion desirable for the treatment of old producing wells. (Fig. 3)

Theory of Application

According to current theory, when the viscous emulsion and sand is pumped against saturated rock at a high rate, resulting pressure will induce fractures along lines of structural weakness including bedding planes, styolites, secondary porosity developments in carbonate rocks, or other types of incipient fractures. When the rock separates, the fracturing fluid and sand are displaced, thereby further extending and widening the opening. It is no longer thought to be necessary to create pressure of the magnitude calculated to lift the overburden. Many believe a movement of rock within a few hundred feet of the pay zone is sufficient to permit the passage of sand grains. Observed low injection pressures in field applications tend to support this concept.

Auxiliary beneficial effects of an acid-kerosine fracture treatment are derived from the high velocity movement of sand when restricted by the fracture surface,[3] and from the hydrochloric acid reacting with carbonate rock as the emulsion breaks. The reaction rate of the 15 per cent acid is retarded because of the nature of the emulsion, and the solvent effect is relatively uniform throughout the extent of the induced fracture or fractures. These actions tend to increase the fracture width and decrease resistance to the flow of fluids.

Results in the Permian Basin

Evaluation of results from a new type treating process is difficult because of the variable and complex nature of a petroleum reservoir. Reservoir rock characteristics are seldom duplicated even in offset wells. A system of grading production results is necessary, however, and the following standards are used:

New wells . . . successfully fractured new wells are those that produce at a rate not less than the average of other wells in the immediate area.

Old wells . . . successfully fractured old wells are those that have returned the cost of the remedial work, and are producing at a higher rate than before the remedial work was initiated.

This report includes 48 fracture treatments in 20 fields and 4 wildcats. Formations treated were the Yates, Grayburg, Queens Sand, San Andres, Drinkard, Clearfork, Blinebry, Abo, Lower Wolfcamp, Pennsylvania, and Devonian. Nearly a third of the wells fractured were completions in the San Andres dolomite. Employing the previously discussed method of classification, 66 per cent of the old wells treated were rated successful. This figure is not spectacular, however, a study of the failures shows that, as with other new developments, fracture emulsion was used frequently as a "last hope" treatment after all other methods had failed. Other failures were edge wells with poor pay zones and production histories. As fractured wells are widely scattered, and formations so varied in composition, definite conclusions can not be made as to the type of reservoir characteristics from which to expect optimum results.

TABLE 1. Effect of dilution upon viscosity of acid-kerosine emulsion.

Kerosine added per cent by volume	Viscosity centipoises	Decrease in viscosity per cent
0	5000	
5	2167	52.6
10	390	92.2
20	100	98.0
50	43	99.0

A recent remedial treatment that gave an unusual production increase was in a San Andres well of the Fuhrman field in Andrews County, Texas. This well had been completed in 1948 for a flowing potential of 155 bbl oil per day after acidizing with 4000 gal. The pay zone was a relatively clean dolomite with 35 ft of good saturated porosity. Production had declined to 8.0 bbl oil per day, pumping, just prior to the remedial work. Five thousand gallons of acid-kerosine emulsion and 2500 lb

The Authors

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C. H. Hutchins is a project engineer for The Western Company. He joined the company as acidizing engineer in 1948, accepting his present position this year. He attended Oklahoma A. and M. and University of Oklahoma, graduating with a BS degree in petroleum engineering in 1942. He worked for Dowell, Inc., for two years before joining Western.

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Foster Drilling Co., Cushing, Okla., found its operating costs soaring with the original power. Having been completely satisfied by the performance of two Cat* D13000 Diesels on another rig, the company repowered with D337s. Drilling depth was increased, operating and fuel costs were decreased, and down time was held to a minimum.

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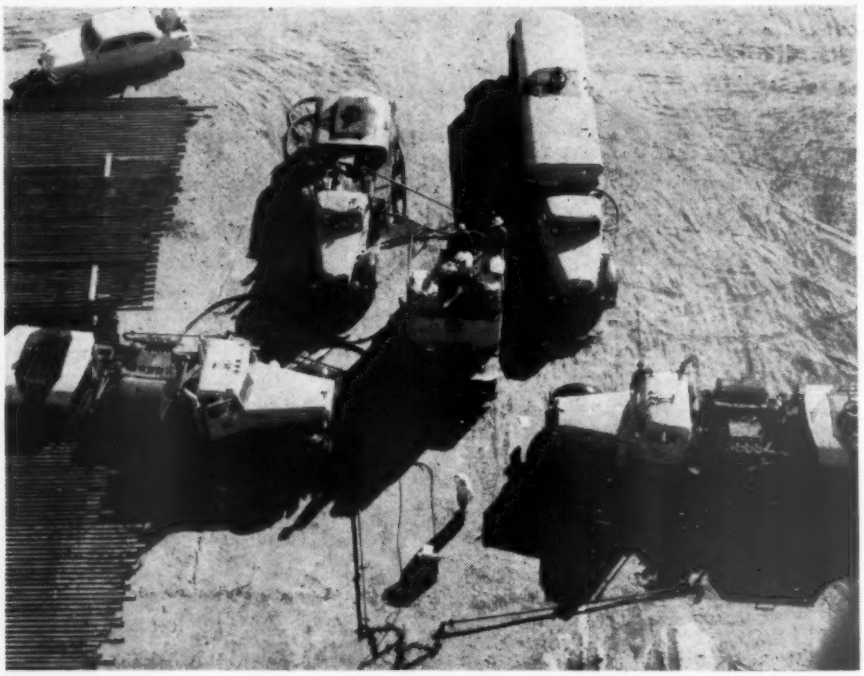

FIG. 5. HEAVY duty pumping equipment on location for a fracturing treatment. A specially designed trailer (center) is used for homogenizing sand and acid-kerosine emulsion.

of sand were injected at 6 bbl per minute, with an average surface pressure of 1600 psi. The well was closed-in four hours and swabbed; it cleaned-up quickly and started flowing at a rate of 85 bbl oil per day. After three weeks of continuous production the well flowed 51 bbl of oil on a 12-hour test.

Eighty-five per cent of the new completions fractured were successful. Four of the failures were wildcats that were plugged and abandoned at a later date. These results indicate that the acid-kerosine emulsion is effective in pay zones containing the potential capacity to produce at a higher rate.

Another factor contributing to a higher percentage of successful applications in new wells is the improved modern completion techniques wherein only the pay zone is exposed in the well bore. This permits control of the interval of injection. Numerous old wells fractured had more than 100 ft of open hole, and fracturing may have occurred in a barren zone.

An example of a successful application in a new well is that of a Grayburg formation completion in the old McElroy field of Crane County, Texas. The productive rock is a clean dolomite, however, acidizing has never given results comparable to that of shooting with well explosives. The pay zone was fractured through a hydraulic straddle packer with 5000 gal of fracture emulsion and 2500 lb of Ottawa sand. Production after fracturing has been 50 bbl oil per day, pumping. This is considerably better than nearby wells that were completed by shooting or acidizing.

Results in Hugoton Gas Field

A majority of 52 acid-kerosine fracture treatments in the Kansas Hugoton gas area have been in wells drilled on the west and northeast flanks of the field (see Fig. 4). The productive formations, members of the Chase group, are: Herrington dolomite, which is generally a fine crystalline, tan to buff dolomite, containing anhydrite and some chert; Herrington grades into a sandy dolomite to the west. The Krider dolomite is a gray to tan granular dolomite containing varying amounts of silica, anhydrite, and argillaceous material. The Winfield formation is a gray to tan argillaceous dolomitic limestone with chert. Toward the west there is an erratic sand pay development in the top of the Winfield. According to available information there are no fractures in these pay zones.

Acidization of these zones presented problems from which grew controversial completion techniques that were progressively more lengthy and involved. Frequently an acid treatment reduced the natural rate of production which could be restored only after a series of "washes" using weak solutions of acid. A popular theory is that the blocking effect of acid treatments in these wells is caused by loosened sand, silt, and clays that may be composed of anhydrite, dolomite, and silicates that tend to bridge in the flow channels.

On the northeast side of the field the wells fractured with the modified emulsion were compared with nearby wells completed by acidizing. The average treating and testing time for the fractured wells was five days; for similar completions using acid, 19 days were required. The average 72/20 open-flow blowdown test for the fractured wells was 10,480,000 cu ft per day as compared to an average of 6,500,000 cu ft per day for the acidized wells. These results indicate that the fracture treatments with the acid-kerosine emulsion will establish a more effective drainage system, and clean up much faster after a treatment.

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Natural gas production reached a new high in 1952 of 8.6 trillion cubic feet. This was a gain of 8.4 per cent over 1951.

Another group of fractured wells situated on the western edge of the field were compared with inside acidized wells completed four to seven years previously. Pay zones of the fractured wells are very poor, however, the average 72/20 open-flow blowdown tests was 3,145,000 cu ft per day. The average for the acidized offsets, which are more favorably situated, was 3,370,000 cu ft per day. Fast clean-up times were noted on the fractured wells; no data were available for those treated with acid. State deliverability tests[4] had been taken on seven of the fractured wells, and deliverability gas volumes averaged 17.1 per cent of the open-flow blowdown volumes. Deliverabilities of the acidized well averaged 14.7 per cent. All deliverability values were those taken at completion of the respective wells. Although these results are not conclusive because of the limited number of wells involved, indications are that permeability induced by fracture emulsion is capable of a more sustained flow capacity than that of acidized wells.

Conclusions

Based on presently available field data modified acid-kerosine emulsion is a highly successful fracturing medium. Results are especially good in limestone and dolomite where acid provides an additional benefit. Production has been substantially increased in wells that were capable of producing at a higher rate. Permian Basin treatments were in pay zones containing characteristics so variable that definite conclusions regarding the type of rock that would give the best results cannot be made. Results obtained from fracturing productive zones of the Hugoton field with the modified emulsion show a higher sustained flow rate, and a more rapid clean-up than acid treatments in similar wells.

Acknowledgment

The authors with to express their appreciation to the Kansas Natural Gas Company and the Northern Pump Company for permission to utilize production results from their records. They also desire to acknowledge the assistance and advice of the research, field operations, and engineering sections of The Western Company.

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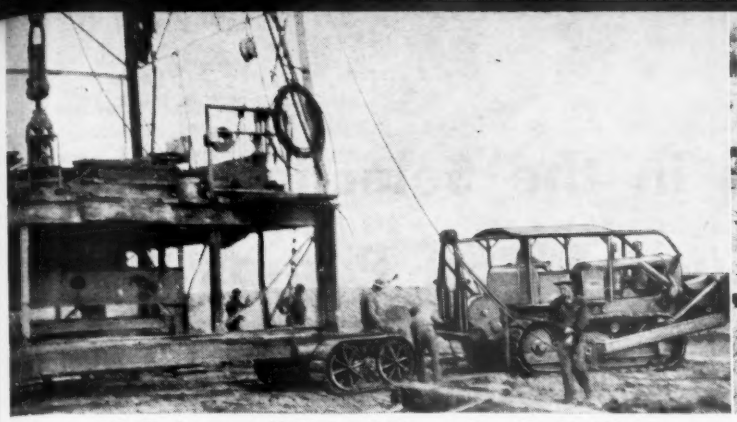

Drill rigs are skidded quickly, easily with this HD-15 doing the pulling. Positive Seals on truck wheels, idlers and support rollers give sure protection from dirt, grime and moisture — require lubrication only once every *1,000 hours!*

This HD-15 with side boom is placing pipe for a pumping plant. Great stability of tractor permits booming way out — rack and counterweights are mounted high for maximum clearance on rough ground or in deep mud.

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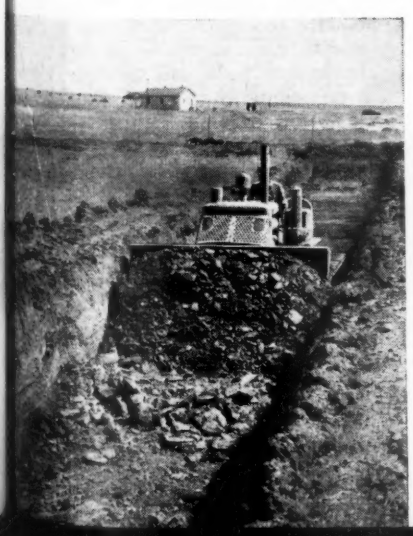
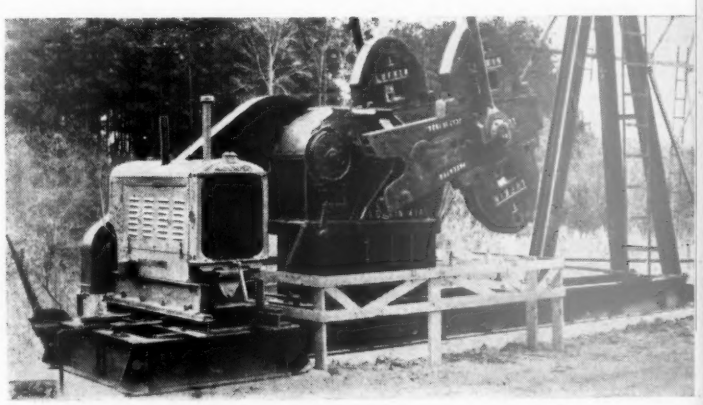


Slush pits are built deep, narrow — and in a hurry with this HD-9 Tractor with 9X no push-beam dozer. Blade is mounted directly on tractor main frame, providing steeper penetration angle.



It costs less to pump with Allis-Chalmers power units. Available in four sizes through Fred E. Cooper Inc., Allis-Chalmers power unit distributor to the oil industry.

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Some Considerations in the Selection and Application of Sucker Rod Pumps

Bore size is a principal factor influencing magnitude of sucker rod load and the size of surface equipment

KENNETH N. MILLS*

SUCKER rod pump is one of the key factors controlling cost of producing an oil well. Its bore size is one of the principal factors influencing magnitude of sucker rod load and size of surface equipment required to produce the well. Thereby, it directly influences capital investment required to produce a well. Ability of the pump to resist deterioration resulting from adverse well conditions and normal wear will influence the cost of maintaining production. This phase of pump performance is influenced by mechancial and metallurgical characteristics of the pump and the design of the pump installation.

Minimum lifting costs should be achieved when all equipment is selected to cope with prevailing well conditions and with sufficient capacity to produce the desired fluid volume in the most economical period of time. To achieve this goal it is essential to have accurate information on the type of drive in producing formation and characteristics of the well fluid. Nature of the driving force in the reservoir and performance characteristics of the well can be used to estimate probable maximum fluid volume to be produced. Type of formation and characteristics of the well fluid can be used as a guide in selection and installation of the pump. These factors will indicate the probable scope of corrosion, sand and gas problems to be encountered in producing the well.

To assure a minimum economical lifting equipment investment the production rate should be established at the lowest value that will achieve desired production in the most economical period of time. Selection of a production rate involves some indeterminable variables, as it is influenced by market demand, water production and the availability of lease labor over a prolonged period of time. If lease labor is available over a 16-hour period, a desirable production rate might be one which would produce the desired fluid in 12 hours. This would allow some time for equipment and well maintenance with a small factor of safety for changes in demand.

General effect of production rate on equipment loads and power demand is shown in Fig. 1. This chart illustrates the variation of production rate, pumping unit peak torque load and power requirements with plunger diameter for a 3500-ft well. In this chart it will be noted that the equipment loads and therefore equipment costs increase as the production rate is increased. Also, amount of power required to pump the well increases as the production rate is increased. Importance of the relationship between production rate and power requirements is dependent on the type of power used to produce the well. If the power source is a gas engine, principal effect of increasing the production rate is to increase the size of the engine required to pump the well. If the well is pumped with purchased electric power increasing production rate will increase the power demand. This will increase the cost of the power if the power rate is based on either connected or measured demand. Consequently, power cost per barrel of fluid produced will be increased. If the wells are produced with lease generated electric power excessive production rates will necessitate excessive generating capacity. This will increase the investment in power generating equipment and, consequently, will increase production costs.

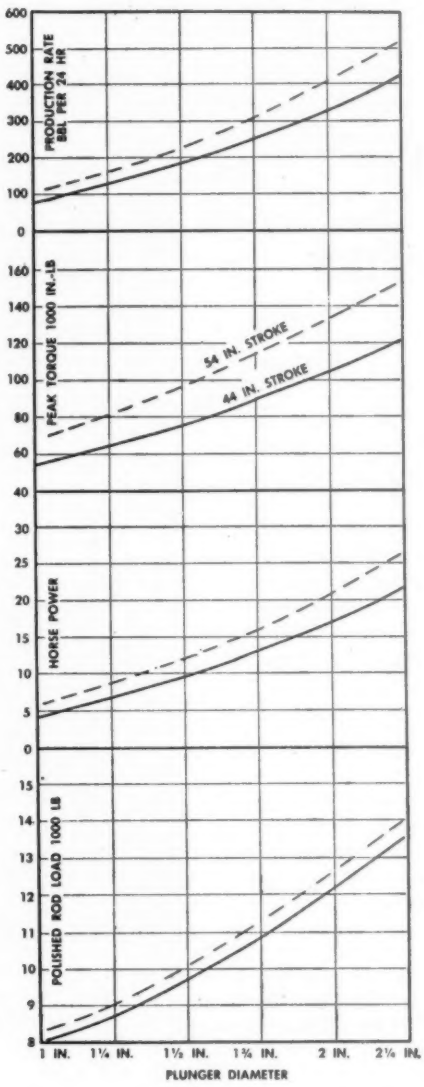


FIG. 1.

When the production rate is established, a practical combination of plunger diameter, stroke length and pumping speed must be selected to achieve this production rate. As production rate is a direct function of pumping speed, it would appear that the most economical installation would be achieved if the well is pumped at a high speed. This would permit the use of a smaller pump plunger and a shorter surface stroke length. Within limits this approach will result in reduced equipment investments. Maximum speed must be limited, however, to a value which will not create excessive sucker rod loads. As sucker rod string is reciprocated, it is subjected to inertia forces and vibratory forces, and each of these effects place a ceiling on pumping speed.

Maximum practical pumping speed considering inertia forces is one which will not cause the polished rod hanger to "run away from" the polished rod clamp on the down portion of the stroke cycle. If a higher pumping speed is used, the polished rod hanger and clamp will part, and they contact later in the stroke cycle, sucker rods will be subjected to a damaging shock load. The approximate value of this ceiling on pumping speed is expressed by the following equation and is shown graphically in Fig. 2.

$$N = \sqrt{\frac{60{,}000}{L}}$$

Where:

N = maximum number of strokes per minute

L = length of stroke, inches

This equation assumes friction be-

*Chief Engineer, Walter O'Bannon Company, Tulsa, Oklahoma.

EXCLUSIVE

tween rods and tubing to be normal. If this friction loss is increased by a crooked hole, an improperly set packer or anchor, excessive pump friction or paraffin, maximum speed must be reduced to allow for reduced rate of sucker rod fall caused by these conditions.

Maximum practical pumping speed considering sucker rod vibrations is one that will not induce high vibratory stresses into the sucker rod string. This ceiling on pumping speed is a depth function and must be based on experience. Its values are shown graphically in Fig. 3.

As most sucker rod failures are the result of fatigue, maximum sucker rod life will be realized when operating at speeds below maximum pumping speed. Sucker rod life will increase as pumping speed is decreased, because decreasing pumping speed reduces magnitude of the sucker rod load, decreases range of stress and decreases number of stress applications per unit of time. Reducing range of stress increases service endurance limit of the sucker rod material and thereby increases its ability to withstand pumping loads. Reducing number of stress applications per unit of time will increase service life of sucker rods, because all fatigue failures occur after the material has been subjected to some definite number of stress applications.

Production chart shown in Fig. 4 can be used to select stroke length, pumping speed and plunger combinations to give the desired production rates. This chart is based on 80 per cent efficiency and the stroke length lines do not extend beyond maximum pumping speed for each stroke length. Solid portions of stroke length lines correspond to reasonable pumping speeds and are limited to speeds that should give good sucker rod life. Dotted portions of the stroke length lines cover pumping speeds between those desirable for good sucker

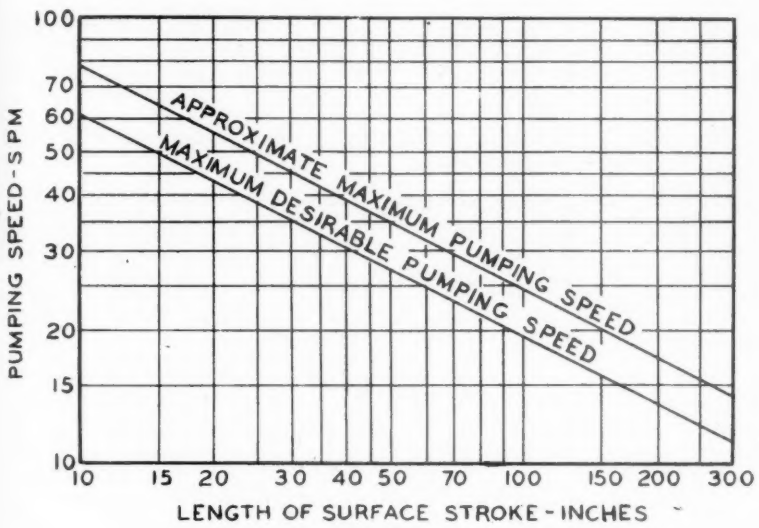


FIG. 2.

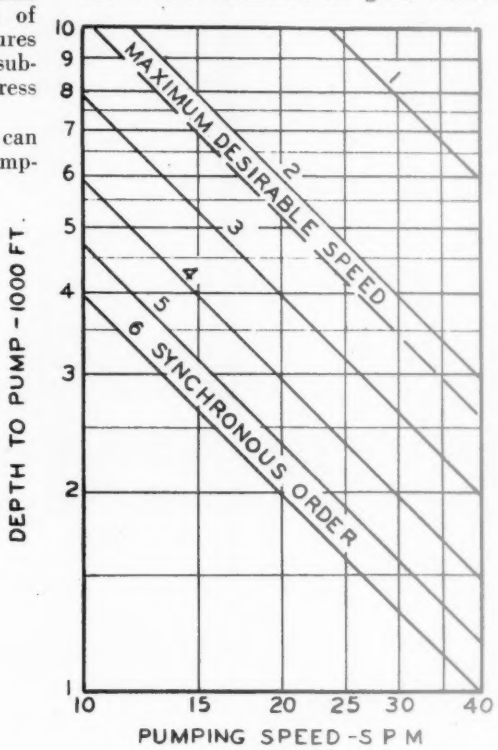
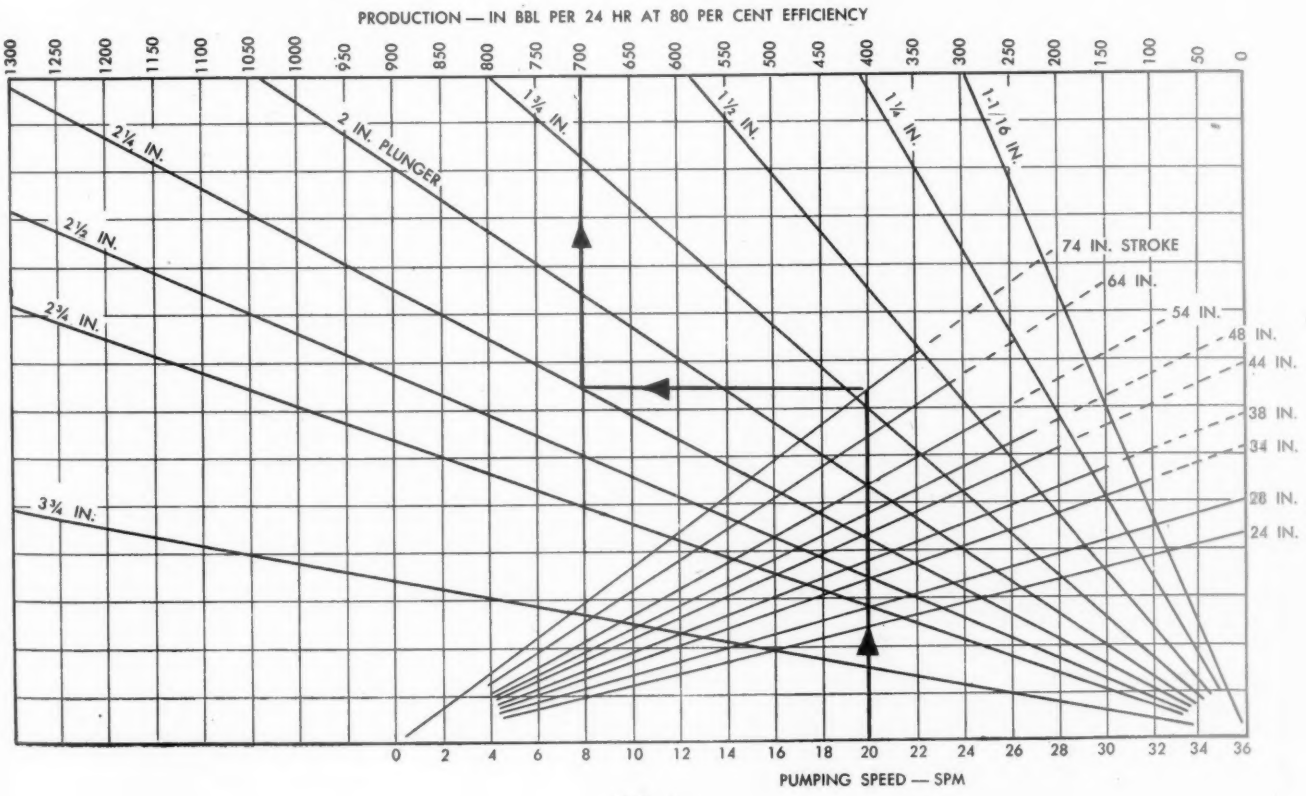


FIG. 3.



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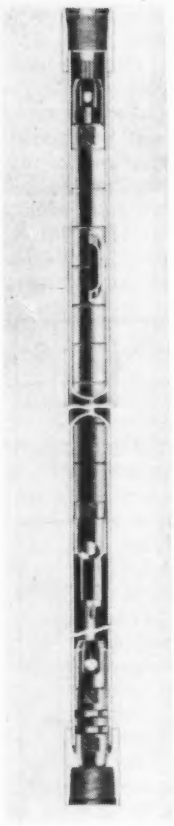

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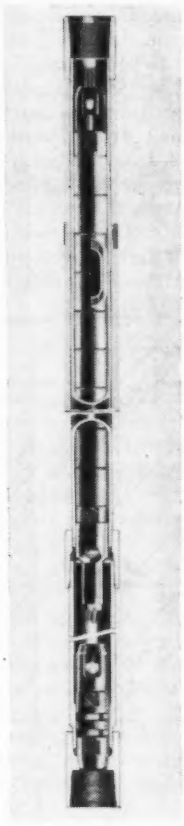

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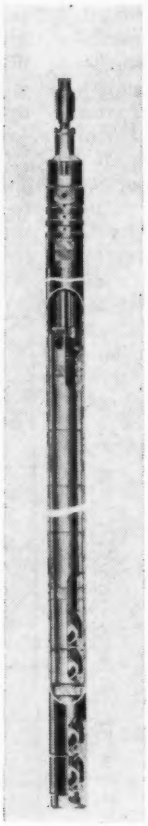

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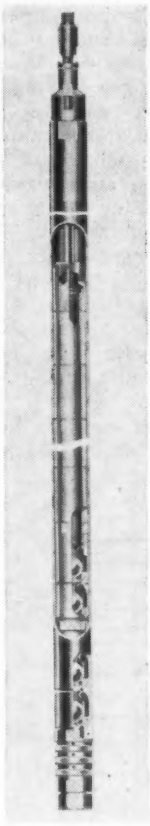

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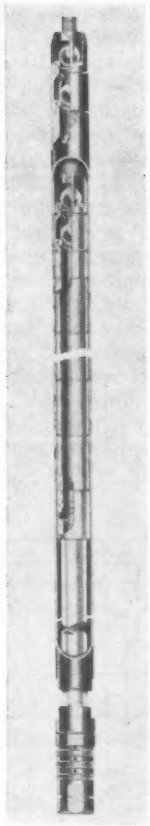

FIG. 9.

TABLE 1. Rod and tubing stretch, inches.

Well Depth 3000 ft								Well Depth 4000 ft						
Tubing			Rods				Pump plunger size	Rods			Tubing			
3	2½	2	1	⅞	¾	⅝		⅝	¾	⅞	1	2	2½	3
—	1	1	2	2	3	4	1	7	5	4	3	2	1	1
1	1	1	2	3	4	6	1¼	11	8	6	4	3	2	1
1	1	2	4	5	6	9	1½	16	11	8	6	4	3	2
1	2	3	5	6	8	12	1¾	22	15	11	8	5	4	3
1	2	3	5	6	9	13	1 25/32	22	16	11	9	5	4	3
2	3	—	6	8	11	16	2	28	20	14	11	—	5	3
2	3	—	8	10	14	—	2¼	—	25	18	14	—	6	4
3	—	—	10	13	17	—	2½	—	31	23	17	—	—	5
4	—	—	12	15	21	—	2¾	—	37	27	21	—	—	6
Well Depth 5000 ft								Well Depth 6000 ft						
1	2	3	4	6	8	11	1	16	11	8	6	4	3	2
2	3	4	7	9	12	17	1¼	25	17	13	10	6	4	3
3	4	6	10	13	17	25	1½	36	25	18	14	8	6	4
4	6	8	13	17	24	34	1¾	49	34	25	19	11	8	6
4	6	8	14	18	24	35	1 25/32	50	35	26	20	12	9	6
5	7	—	17	23	31	44	2	64	44	33	25	—	11	8
7	9	—	22	29	39	—	2¼	—	56	41	31	—	14	10
8	—	—	27	35	48	—	2½	—	69	51	39	—	—	12
10	—	—	33	43	58	—	2¾	—	84	61	47	—	—	14
Well Depth 7000 ft								Well Depth 8000 ft						
3	4	5	8	11	15	22	1	28	20	14	11	7	5	3
4	6	8	13	17	24	34	1¼	44	31	23	17	10	7	5
6	8	11	19	25	34	49	1½	64	44	33	25	15	11	8
8	11	16	26	34	46	67	1¾	87	60	44	34	20	15	10
8	12	16	27	35	48	69	1 25/32	90	62	46	35	21	15	11
10	15	—	34	44	60	87	2	113	79	58	44	—	19	13
13	19	—	43	56	76	—	2¼	—	100	73	56	—	24	17
Well Depth 9000 ft								Well Depth 10,000 ft						
4	6	8	14	18	25	36	1	44	31	23	17	10	8	5
7	9	13	22	29	39	56	1¼	69	48	35	27	16	12	8
10	14	19	31	41	56	80	1½	99	69	51	39	23	17	12
13	19	26	43	56	76	110	1¾	136	94	69	53	32	23	16
13	19	27	44	58	79	114	1 25/32	140	98	72	55	33	24	17
Well Depth 11,000 ft								Well Depth 12,000 ft						
6	9	13	21	27	37	53	1	64	44	33	25	15	11	8
10	14	20	33	43	56	84	1¼	100	69	51	39	23	17	12
14	20	28	47	62	84	120	1½	143	100	73	56	34	24	17
19	28	39	64	84	114	164	1¾	195	136	100	76	46	33	23
20	29	40	66	87	118	170	1 25/32	202	141	103	79	47	34	24

rod life and maximum pumping speed. Stroke and speed combinations covered by this portion of curves should not be used if maximum economy is to be achieved. Production values shown on this chart are not corrected for rod and tubing stretch and overtravel.

Production values obtained from Fig. 4 can be corrected for stroke loss resulting from rod and tubing stretch and stroke gain resulting from plunger overtravel by determining correct values of these factors from Tables 1 and 2 and modifying production rate as indicated by the formula

$$P = \frac{PR \times (L - S + O)}{L}$$

Where:

P = corrected production rate
PR = production rate from Fig. 3
L = length of surface stroke, inches
S = rod and tubing stretch, inches
O = plunger overtravel, inches

Table covering rod and tubing stretch is based on the formula:

$$S = 0.173\, A_P D^2 \left[\frac{1}{A_R} + \frac{1}{A_T}\right]$$

Where:

S = rod and tubing stretch, inches
D = depth to pump, 1000 ft
A_P = gross plunger area, sq in.
A_R = cross-sectional area rods, sq in.
A_T = cross-sectional area tubing, sq in.

Table covering plunger overtravel is based on the formula:

$$O = \frac{L\,(DN)^2}{45{,}000}$$

Where:

O = overtravel, inches
L = length of surface stroke, inches
D = depth to pump, 1000 ft
N = strokes per minute

The following example illustrates how the rod stretch data shown in Table 1 can be applied to tapered sucker rod strings. Consider a 5000 ft well with a 1½-in. bore pump and a rod string composed of 3100 ft of ⅝-in. rods and 1900 ft of ¾-in. rods. Using stretch values from Table 1 the rod stretch is determined as follows:

Stretch in

$$\text{⅝ in. rods} = 25 \times \frac{3100}{5000} = 15.5 \text{ in.}$$

Stretch in

$$\text{¾ in. rods} = 17 \times \frac{1900}{5000} = 6.5 \text{ in.}$$

total rod stretch = 22. in.

Size and type of pump selected can influence frequency and cost of well servicing. If tubing size is established and a large bore pump is selected, a tubing type pump may be required. This type pump affords the maximum plunger diameter for a given tubing size, because the pump barrel is attached directly to the lower end of the tubing. Plunger and traveling valve assembly are attached directly to the lower end of the rod string and are lowered into the pump on the rod string. Lower end of the plunger can be fitted with a number of devices that can be used to pull the standing valve out of the well

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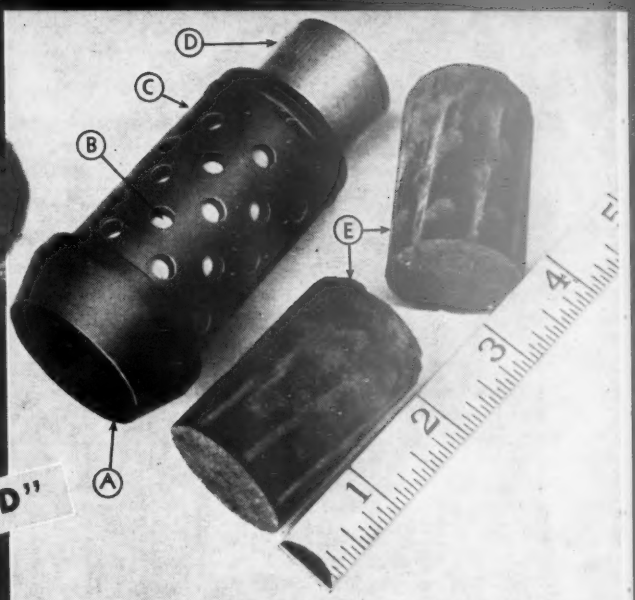

PGAC Side Wall Coring Chamber. A—Cutter. B—Mud Extrusion Ports. C—Core Barrel. D—Powder Chamber and Retrieving Cable Housing. E—Note large size of PGAC core samples.

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TABLE 2. Plunger overtravel, inches.

Well Depth 3000 ft

Surface stroke	Strokes Per Minute													
	4	6	8	10	12	14	16	18	20	22	24	26	28	30
34	–	–	—	—	1	1	2	2	3	3	4	5	5	6
42	–	–	—	—	1	2	2	3	3	4	5	6	7	7
44	–	–	—	—	1	2	2	3	4	4	5	6	7	8
48	–	–	—	—	1	2	3	3	4	5	6	7	8	9
54	–	–	—	1	2	2	3	4	4	5	6	7	9	10
64	–	–	—	1	2	3	3	4	5	6	7	9	10	12
74	–	–	—	2	2	3	4	5	6	7	9	10	12	—
84	–	–	1	2	2	3	4	6	7	8	10	11	—	—
86	–	–	1	2	3	3	4	6	7	8	10	12	—	—

Well Depth 4000 ft

43	–	–	—	1	2	2	3	4	5	6	7	8	10	11
42	–	–	—	2	2	3	4	5	6	7	9	10	12	13
44	–	–	1	2	2	3	4	5	6	8	9	11	12	14
48	–	–	1	2	3	3	4	6	7	8	10	12	13	15
54	–	–	1	2	3	4	5	6	8	9	11	13	15	17
64	–	–	2	2	3	5	6	7	9	11	13	15	18	20
74	–	–	2	3	4	5	7	9	10	13	15	18	21	—
84	–	1	2	3	4	6	8	10	12	14	17	20	—	—
86	–	1	2	3	4	6	8	10	12	15	18	21	—	—

Well Depth 5000 ft

34	–	–	1	2	3	4	5	6	8	9	11	13	15	17
42	–	–	2	2	3	5	6	8	9	11	13	16	18	21
44	–	–	2	2	4	5	6	8	10	12	14	17	19	22
48	–	–	2	3	4	5	7	9	10	13	15	18	21	24
54	–	1	2	3	4	6	8	10	12	15	17	20	24	27
64	–	1	2	4	5	7	9	12	14	17	20	24	28	32
74	–	2	3	4	6	8	11	13	16	20	24	28	32	—
84	–	2	3	5	7	9	12	15	19	23	27	31	—	—
86	–	2	3	5	7	9	12	15	19	23	28	32	—	—

Well Depth 6000 ft

34	–	–	2	3	4	5	7	9	11	13	16	18	21	24
42	–	1	2	3	5	7	9	11	13	16	19	23	26	30
44	–	1	2	4	5	7	9	11	14	17	20	24	28	32
48	–	1	2	4	6	8	10	12	15	19	22	26	30	35
54	–	2	3	4	6	9	11	14	17	21	25	29	34	39
64	–	2	3	5	7	10	13	17	20	25	29	35	40	—
74	–	2	4	6	9	12	15	19	24	29	34	40	—	—
84	1	2	4	7	10	13	17	22	27	32	39	—	—	—
86	1	3	4	7	10	13	18	22	28	33	40	—	—	—

Well Depth 7000 ft

34	–	1	2	4	5	7	10	12	15	18	21	25	29	33
42	–	2	3	5	7	9	12	15	18	22	26	31	36	41
44	–	2	3	5	7	9	12	16	19	23	28	32	38	43
48	–	2	3	5	8	10	13	17	21	25	30	35	41	47
54	–	2	4	6	9	12	15	19	24	28	34	40	46	—
64	1	3	5	7	10	14	18	23	28	34	40	47	—	—
74	1	3	5	8	12	16	21	26	32	39	46	—	—	—
84	2	3	6	9	13	18	23	30	37	44	—	—	—	—
86	2	3	6	9	14	18	24	30	38	45	—	—	—	—

Well Depth 8000 ft

34	–	2	3	5	7	10	12	16	19	23	28	33	38	43
42	–	2	4	6	9	12	15	19	24	29	34	40	47	—
44	1	2	4	6	9	12	16	20	25	30	36	42	49	—
48	1	2	4	7	10	13	17	22	27	33	39	46	—	—
54	1	3	5	8	11	15	20	25	31	37	44	—	—	—
64	1	3	6	9	13	18	23	29	36	44	—	—	—	—
74	2	4	7	10	15	21	27	34	42	51	—	—	—	—
84	2	4	8	12	17	23	31	39	48	—	—	—	—	—
86	2	4	8	12	18	24	31	40	49	—	—	—	—	—

Well Depth 9000 ft

34	1	2	4	6	9	12	16	20	24	30	35	41	48	—
42	1	3	5	8	11	15	19	25	30	37	44	51	59	—
44	1	3	5	8	11	16	20	26	32	38	46	54	—	—
48	1	3	6	9	12	17	22	28	35	42	50	58	—	—
54	2	4	6	10	14	19	25	31	39	47	56	—	—	—
64	2	4	7	11	17	23	30	37	46	56	—	—	—	—
74	2	5	9	13	19	26	34	43	53	64	—	—	—	—
84	2	5	10	15	22	30	39	49	60	—	—	—	—	—
86	3	6	10	15	22	30	40	50	62	—	—	—	—	—

Well Depth 10,000 ft

34	1	3	5	8	11	15	19	25	30	37	43	51	—	—
42	2	3	6	9	13	18	24	30	37	45	54	—	—	—
44	2	4	6	10	14	19	25	32	39	47	56	—	—	—
48	2	4	7	10	15	21	27	35	43	52	—	—	—	—
54	2	4	8	12	17	24	31	39	48	58	—	—	—	—
64	2	5	9	14	20	28	36	46	57	—	—	—	—	—
74	3	6	10	16	24	32	42	53	66	—	—	—	—	—
84	3	7	12	19	27	37	48	60	—	—	—	—	—	—
86	3	7	12	19	28	37	49	62	—	—	—	—	—	—

Well Depth 11,000 ft

34	2	3	6	9	13	18	23	30	36	44	52	—	—	—
42	2	4	7	11	16	22	29	37	45	55	65	—	—	—
44	2	4	8	12	17	23	30	38	47	57	—	—	—	—
48	2	5	8	13	19	25	33	42	52	62	—	—	—	—
54	2	5	9	15	21	28	37	47	—	—	—	—	—	—
64	3	6	11	17	25	34	44	56	—	—	—	—	—	—
74	3	7	13	20	29	39	51	65	—	—	—	—	—	—
84	4	8	14	23	32	44	58	—	—	—	—	—	—	—
86	4	8	15	23	33	45	59	—	—	—	—	—	—	—

with the plunger assembly. A typical tubing pump with a metal plunger is shown in Fig. 5. If the well fluid tends to deposit gyp in the unused section of the pump barrel and the pump has a metal plunger, pump should be fitted with an extension nipple, as shown in Fig. 6. Extension nipple will permit plunger to stroke out both ends of barrel. This will prevent the formation of heavy gyp deposits in the end of the barrel which would interfere with the free removal of the plunger. Also, it distributes the wear evenly over the length of the barrel and permits the installation of oversized plungers to compensate for wear.

Rod type pump was developed to reduce the cost of well servicing incident to pump maintenance. It reduces the servicing costs, because the entire pump assembly consisting of the barrel, plunger, standing and traveling valve is lowered into and removed from the well with the sucker rod string. The pump assembly rests in and seals off on a seating shoe or nipple in the tubing string. As the entire pump assembly is removed to service the pump, possibility of leaving defective parts in the pump requiring a second repair job is reduced to a minimum. Also, possibility of damaging the pump plunger during its trip down the tubing is eliminated because it is protected by the pump barrel.

Rod type pumps have been developed in three basic types of construction to cope with various well conditions. These types of construction are stationary barrel with top hold-down, Fig. 7, stationary barrel with bottom hold-down Fig. 8, and traveling barrel Fig. 9. Top hold-down type pump is well suited to the production of gassy or sandy fluids from moderate depths. This type pump is suited to the production of sandy fluids, because the fluid is discharged from the pump at a point just above the hold-down. As fluid passes over the hold-down, sand cannot settle between the pump and tubing and stick the pump in the tubing. This type pump is not well suited to the production of deep wells because the outside of the pump barrel is situated in fluid under relatively low pressure, and pressure of the fluid column in the tubing tends to expand the barrel. This increases the clearance between the barrel and plunger and increases the rate of fluid slippage, thus decreasing the volumetric efficiency of the pump.

The top hold-down pump can be advantageously applied to wells producing gassy fluids. If the well is producing a non-corrosive fluid, the perforated nipple can be situated just below the seating shoe, as shown in Fig. 10. With the perforated nipple situated in this position the body of the pump will serve as a gas anchor, and the gas anchor pipe on the pump can be shortened or eliminated. Shortening or elimination of the gas anchor pipe decreases the pressure drop in the pump suction system. This decreases the probability of gas being liberated inside of the pump and decreasing its efficiency. If the well is producing a corrosive fluid the perforated nipple should be situated below the

lower end of the pump, as shown in Fig. 11. When the perforations are located in this position, the pump body is surrounded with static oil. This affords the pump body some protection from the corrosive well fluids.

The bottom hold-down pump is well suited to the production of deep wells making sand-free oil. When fitted with a suitable gas anchor, it will perform satisfactorily when producing gassy fluids. As the seal between this pump and tubing is situated at bottom of the pump, outside of the barrel is subjected to tubing pressure, as is the inside of the barrel above plunger. Consequently, the barrel does not expand and increase clearance between barrel and plunger. As that section of the barrel below the plunger is subjected to low internal pressure, the pressure on the outside of the barrel tends to reduce the clearance between the lower end of the plunger and the barrel. Thus the pressure differentials across the barrel are conducive to high volumetric efficiency. This type pump should not be applied to wells producing sandy fluids, because sand will settle into the space between the pump and tubing and stick the pump in the tubing.

If a bottom hold-down pump is applied to a well producing a gassy fluid, it should be fitted with an efficient gas anchor. If a conventional gas anchor pipe is used on the intake of the pump, its diameter should never be less than that of the treads in the hold-down, and its length should be about 10 feet. If it is fitted with a strainer nipple, the total area of the holes in the strainer nipple should not be less than five times the area of the gas anchor pipe. Use of small or long gas anchor pipes and strainer nipples with insufficient openings will create excessive pressure losses in the pump suction system. These pressure losses will cause gas to be liberated by oil, and this will decrease efficiency of the pump. To assure adequate gas separation, the perforated nipple should be situated adjacent to the seating nipple as shown in Fig. 12.

Advantages of the bottom-hold pump in production of deep oil wells have been responsible for the development of a double seal arrangement that prevents sand and stagnant corrosive water from entering the space between pump and tubing. This double seal installation is illustrated in Fig. 13. In this illustration it will be noted that the pump is fitted with a mechanical bottom hold-down and a cup seal similar to a top hold-down at its top end. The top seal engages a seating shoe situated in tubing string and prevents sand from settling into the space between the pump and tubing.

The traveling barrel type pump is idealy suited to the production of sandy fluids from all depths. In this pump design the traveling valve also acts as a sand check valve and keeps sand from settling on top of the plunger when the well is shut down. The churning action of the pump barrel will displace any sand that settles into the space between the pump and tubing. The pressure differentials between the inside and outside of the barrel are identical to those existing in the bottom hold-down pump and therefore it is ideally suited to the production of deep wells. It is not well suited to production of gassy fluids, because fluid must pass through a relatively small pull tube before entering the space above plunger. The pressure drop resulting from fluid friction in its pull tube and gas anchor pipe will be approximately twice that experienced in stationary barrel type pump. This increased pressure drop may cause the fluid to liberate excessive amounts of gas and reduce the efficiency of the pump.

If the well produces a relatively large volume of gas, the ability of the pump to displace the gas entering the pump should be considered at the time the pump bore is selected. If free gas enters the pump, it must be compressed to a pressure equaling the pressure of the fluid column in tubing before the traveling valve can open. If the ratio of the volume of the space between traveling and standing valves at top of the stroke to the volume of the space between the two valves at the bottom of the stroke is too low, the pressure inside pump will not increase sufficiently on the down stroke to open the traveling valve, and the pump will be gas-locked. The above ratio is the compression ratio of the pump. Considering a given pump bore size, the maximum compression ratio is obtained when the pump plunger is fitted with a valve on its lower end, and the traveling and standing valves are spaced close together on the lower end of the stroke. Compression ratio is also affected by the pump bore size and stroke length. Considering a given stroke length, the pump's compression ratio — therefore its ability to handle gas — increases as the pump bore size is increased. Also, increasing the stroke length will increase the ability of the pump to produce gaseous fluids.

Amount of sand passing through the pump can be influenced by the production rate and the design of the mud anchor. Production rate influences the amount of sand passing through the pump, because it controls the fluid velocities in the formation near the well bore and the upward fluid velocity in the well bore. Amount of sand entering the well bore is influenced by fluid velocity in the formation near the well bore and increases as the fluid velocity is increased. Upward velocity of the

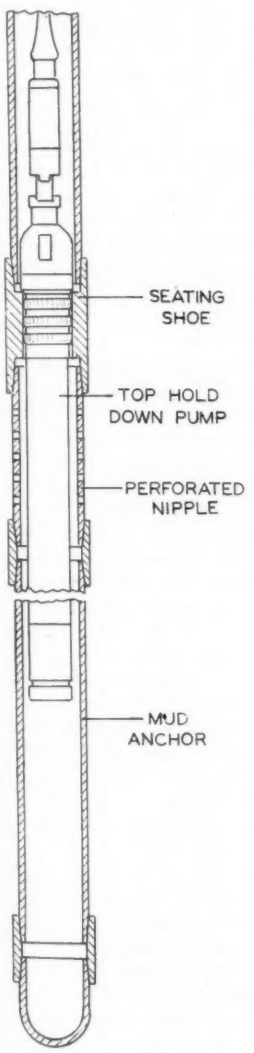


FIG. 10.

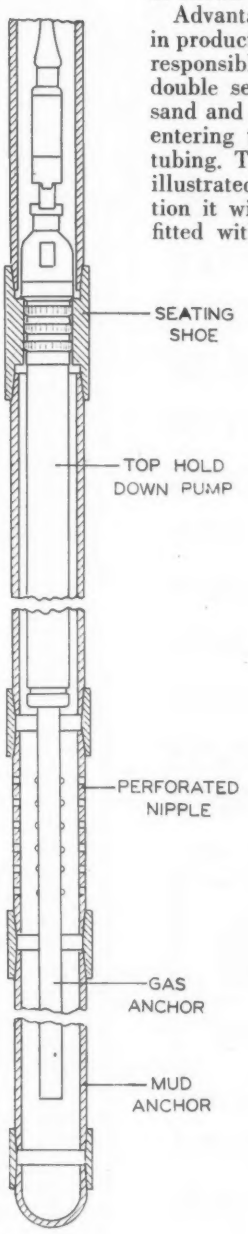


FIG. 11.

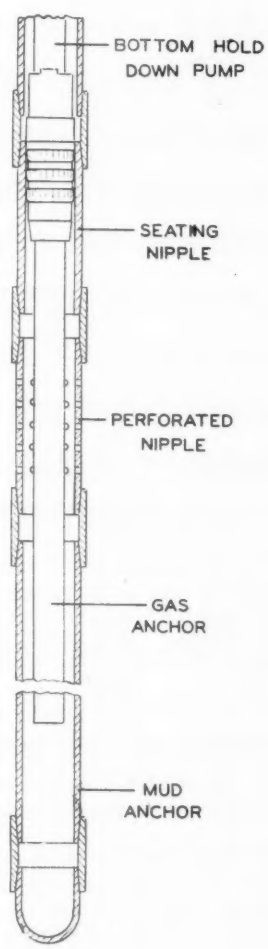
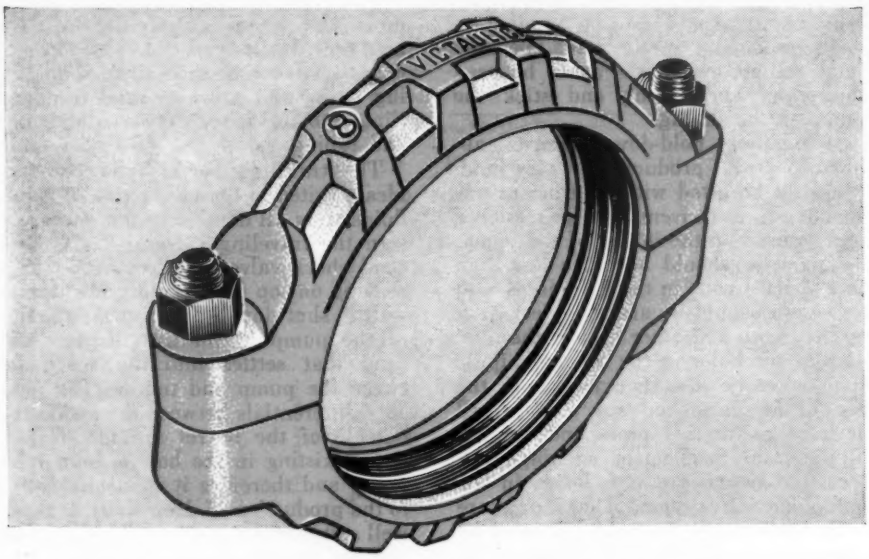


FIG. 12.



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fluid in the well bore influences the amount of sand carried to the pump because density of sand is greater than that of fluid and consequently sand tends to settle to the bottom of the hole. The settling rate or velocity of fall of the sand particles is dependent on their size and shape and increases as the size of the particle increases. If absolute velocity of fall of a particle is less than upward velocity of fluid, it will be carried upward into the pump. If its absolute velocity of fall is greater than velocity of fluid it will fall to the bottom of the well and therefore will not pass through the pump. As the velocity of well fluid influences the amount of sand carried to the pump, wells producing sandy fluids should be pumped at the lowest practical rate.

If a well producing a sandy fluid is fitted with a conventional closed end mud anchor, sand will settle out in the mud anchor until the sand level inside mud anchor has reached lower end of the gas anchor pipe. When the sand level reaches lower end of the gas anchor, all the sand entering the tubing will be drawn into the pump. If the mud anchor does not extend to the bottom of the hole, amount of sand passing through the pump can be reduced to a minimum by using a mud anchor similar to the design shown in Fig. 14. As this mud anchor is partially open at its lower end, sand that settles out in the mud anchor can fall into the open hole below the anchor and will not fill up the lower end of the mud anchor. The slotted bull plug on its lower end will prevent pump parts from falling into the open hole in the event of a mechanical failure in the pump. This mud anchor design will not function, if the lower end of the mud anchor is covered with foreign material. Also, it reduces effectiveness of the gas anchor and should not be used in wells producing extremely gassy fluids.

Relative amounts of water and oil produced from a water drive field may be influenced by rate of withdrawal. In an ideal water drive reservoir water exists in the lower portion of the reservoir, and it contacts oil in a uniform plane at a constant elevation. When a well is drilled and completed in the oil-saturated section of the formation a reasonable distance above the water bearing section, pressure of water on oil drives it to the well bore. If the well is produced at a low rate, water level in the formation tends to increase at a uniform rate and maintain a uniform pressure in oil bearing section of the formation. If production rate is high, resulting pressure differentials in the formation encourage encroachment of water on the well bore. This increases amount of water produced from the well.

During flowing life of wells in water drive reservoirs, rate of water encroachment is usually controlled by imposing a back pressure on the well to control its rate of flow. For several years this principle has been applied to pumping wells in East Texas fields to eliminate harmful effects resulting from unrestricted flow characterized as "heading."

The control method as applied to these wells uses a sub-surface choke below the pump to control rate of flow into annulus above a packer. The pump receives its fluid from the reservoir in the annulus. General arrangement of subsurface equipment used in these installations is shown in Fig. 15. In this illustration it will be noted that choke assembly is attached to lower end of the pump and serves as a hold-down and can be removed from the well with sucker rods. All fluid produced from the well must pass through the choke. When the well is shut down, the well fluid will pass through the choke until pressure of fluid column in the annulus equals pressure on down-stream side of choke. During this phase of operation, fluid passes through the choke and out into the annulus through perforations and slots above choke. When the well starts pumping, fluid passes from annulus through these perforations and from the well through the choke to the pump. Consequently, rate of flow from formation to well bore is under constant control. This system of water control has achieved remarkable results in the East Texas field when applied before excessive rates of water production occur. It should be equally applicable to any water driven reservoir with similar reservoir characteristics. * * *

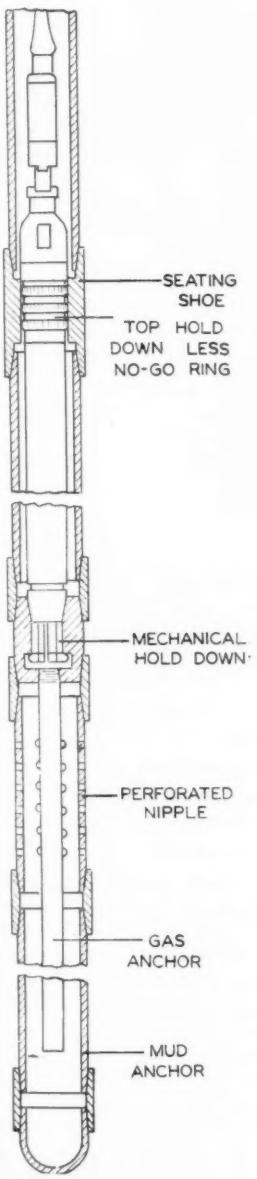

FIG. 13.

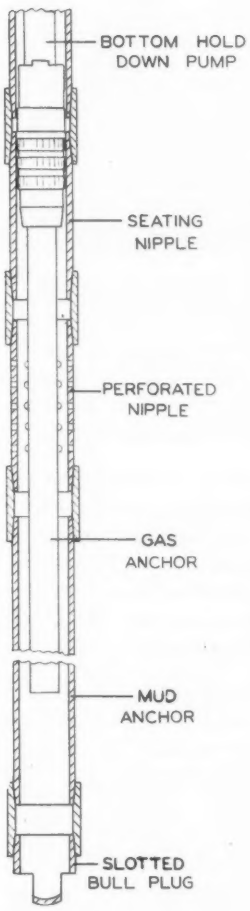

FIG. 14.

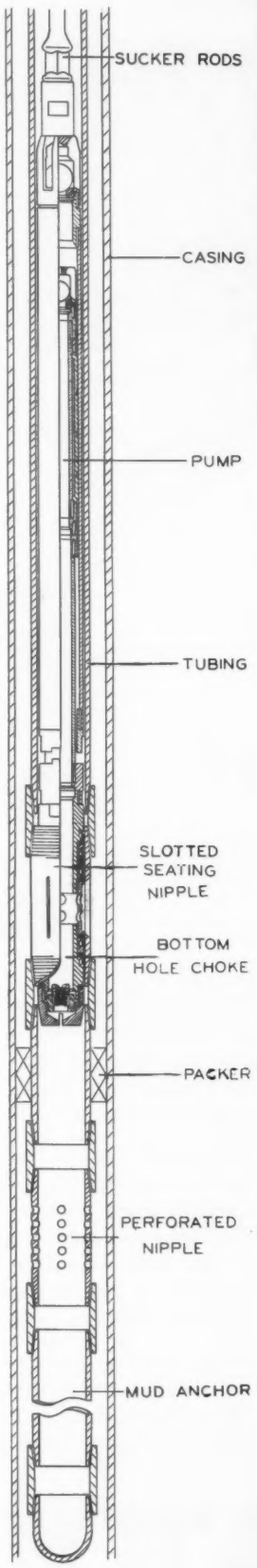

FIG. 15.

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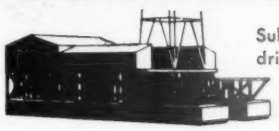
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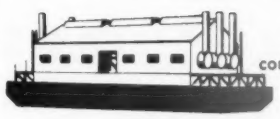
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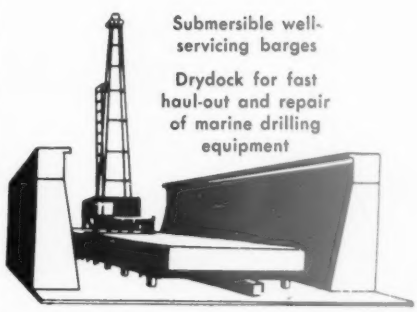
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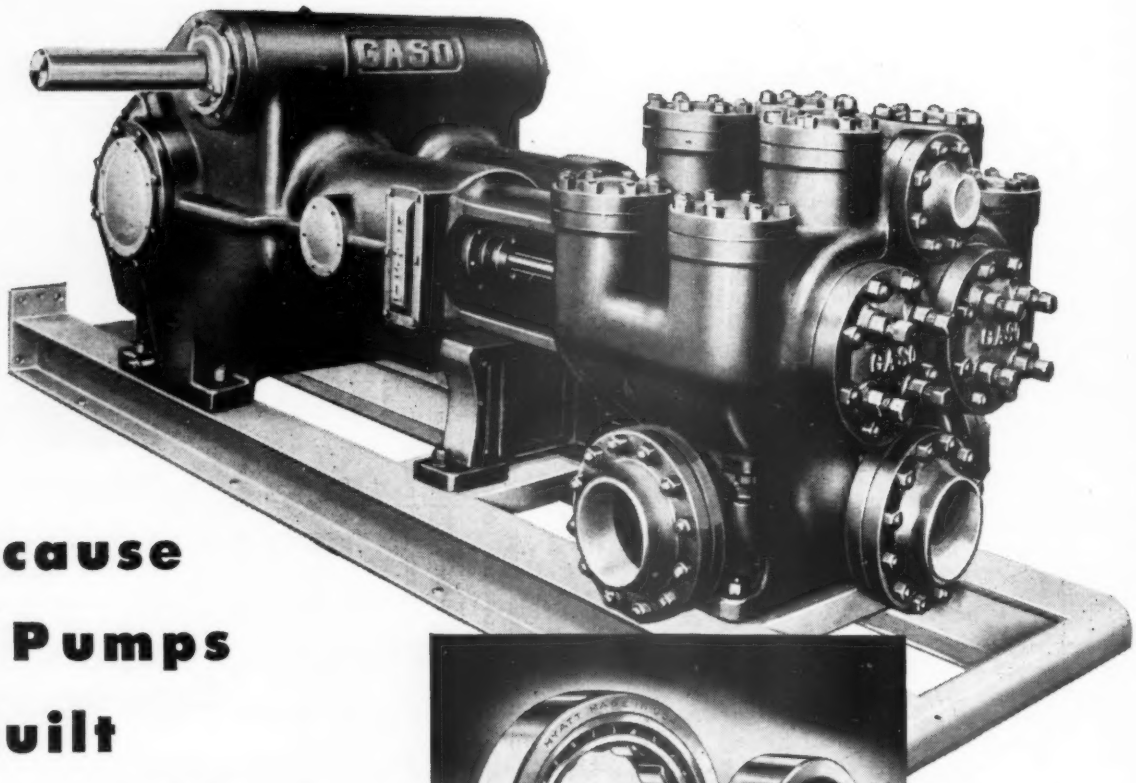

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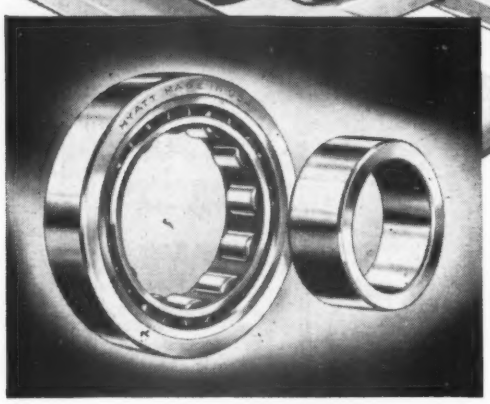

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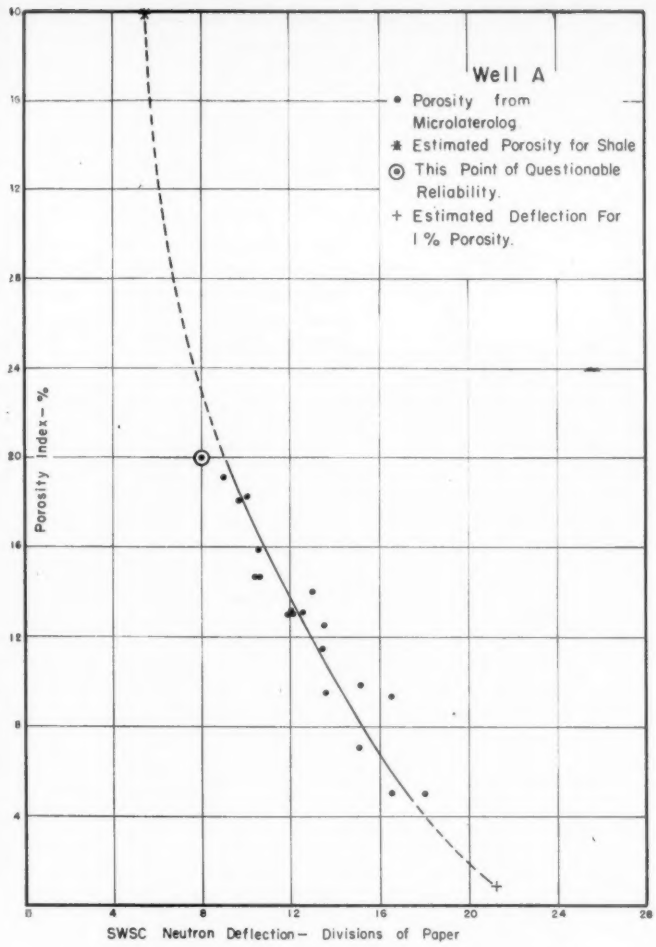
Well A
• Porosity from Microlaterolog
✱ Estimated Porosity for Shale
⊙ This Point of Questionable Reliability.
+ Estimated Deflection For 1 % Porosity.
Porosity Index — %
SWSC Neutron Deflection — Divisions of Paper

FIG. 1. One of first attempts to correlate neutron deflections with porosities computed with Micro-Laterolog.

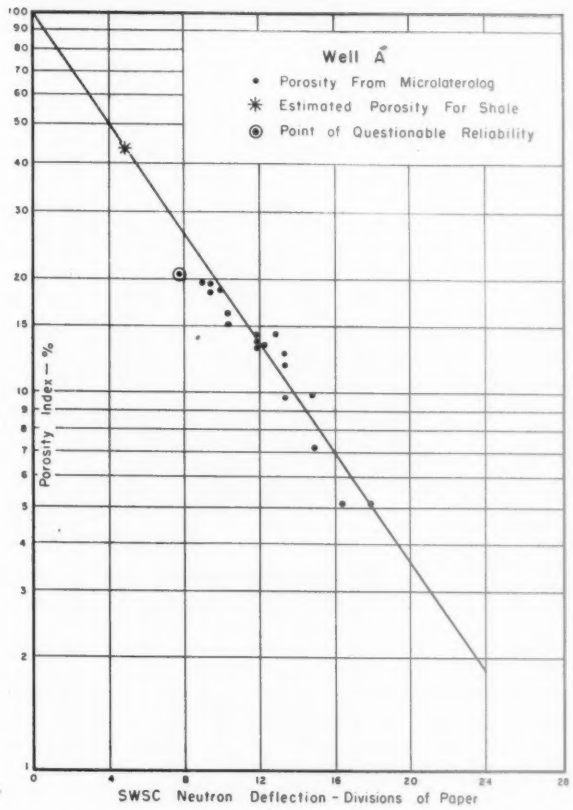
Well A
• Porosity From Microlaterolog
✱ Estimated Porosity For Shale
⊙ Point of Questionable Reliability
Porosity Index — %
SWSC Neutron Deflection - Divisions of Paper

FIG. 2. Same points plotted on semi-log graph with porosities in logarithmic coordinates and neutron deflection in arithmetic.

Experimental Basis For Neutron Logging Interpretation

Promise of better porosity evaluation of formations offered by the new neutron log

J. T. DEWAN* and L. A. ALLAUD*

Summary

A new neutron logging device has recently been introduced. It was especially designed to detect "gamma rays of capture" on the one hand, while discriminating against "scattered" and "natural" gamma rays on the other. Experience has shown that response to hydrogen content (hence porosity) is easily predictable. The experimental results are presented and simple empirical methods for porosity determination are offered.

*Schlumberger Well Surveying Corporation, Houston, Texas.

Principle of Neutron Logging

NEUTRONS are electrically neutral particles. Their mass is, approximately, that of the hydrogen atom. They are emitted at high velocity from a special source and collide elastically with atoms of different substances. Each collision slows them down, and after a number of collisions, their velocity has decreased to the point where they can be absorbed, or "captured" by an atom of hydrogen, silicon, sodium, chlorine, etc. Each capture is accompanied by the emission of very energetic gamma rays, called "gamma rays of capture." These gamma rays can easily be detected by a Geiger-Mueller counter placed at a certain distance from the source.

How far the neutron will travel before being captured depends upon the nature of the atoms it encounters. On heavy atoms, it will bounce off without much loss of speed. On the contrary when striking hydrogen atoms, having a mass almost equal to its own, it will lose a great part of its energy. Consequently, if the concentration in hydrogen in the vicinity of the source is large, the neu-

EXCLUSIVE

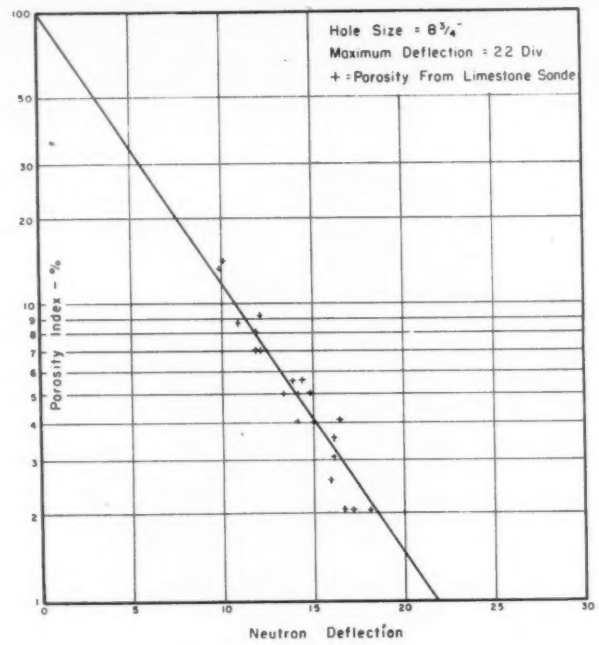

FIG. 3. Neutron deflections were plotted versus limestone sonde derived porosities.

tron will be immediately slowed down and captured. The gamma rays of capture are emitted close to the source, too far from the counter to be detected. On the contrary, if the concentration in hydrogen is small the neutrons will travel relatively far, some of them will be captured in the vicinity of the counter, and the gamma rays of capture will be detected. Thus, the detector will "see" relatively few gamma rays where the hydrogen concentration is large, and many when this concentration is small.

There is a definite relationship between hydrogen concentration and liquid filled porosity, and the neutron log will show high counting rates opposite formations of low porosity and vice versa. The presence of a bore hole filled with mud will complicate matters to a certain degree, yet as long as its diameter is not exceedingly large and remains constant, it can be discounted for a comparative study of the porosity at different levels.

Gamma rays of a different nature are also present in the vicinity of the counter. They are:

1. Gamma rays emitted by the source and scattered by adjacent substances. This scattering takes place mostly in the bore hole or on the walls. Rays thus generated are much less energetic than the previously discussed "gamma rays of capture."
2. Natural gamma rays, emitted by the formations. They are the rays that are recorded in regular gamma ray logging operations. Total amount of this radiation is generally small.

It appears from the foregoing that only gamma rays of capture are of interest in neutron logging. Consequently, it is essential to eliminate, or at least to minimize, the effects of the scattered and of the natural gamma rays.

In the new instrument, advantage has been taken of the difference of energy level between scattered and gamma rays of capture. A shielded Geiger-Mueller counter, of special internal construction, has been provided which detects the energetic gamma rays of capture, but is insensitive to the scattered rays for all practical purposes. It is also extremely insensitive to the natural gamma rays. Furthermore, the relative importance of the latter is reduced by the use of a powerful neutron source which renders the radiation of capture so large that in comparison the natural radiation is negligible.

Experimental Results—Response to Porosity

Experience has shown that it was indeed worthwhile to discriminate between the different components of the radiation. Whereas previous porosity determinations made from neutron logging had been hampered by the complexity of the total radiation, it was relatively easy to correlate the porosity with the response of the new instrument.

Several methods were used to obtain this correlation. Neutron log deflections were compared to the following:

(1) Porosities computed from MicroLaterologs.[1]

(2) Porosities computed from limestone sonde logs.[2]

(3) Porosity determined by core analysis.

Although the last method might at first glance appear as the most reliable, the value of the first two should not be minimized. These methods are based on electrical measurements and they make use of physical properties completely different from those on which the neutron method is based. Consequently, if for a given example an unequivocal correlation is obtained, the verification is certainly excellent. Methods based on electrical measurements have, furthermore, the following advantages upon direct comparison with core analysis:

1. The abundance of data is considerable. Many thousand feet have been logged continuously, whereas, core analyses are generally conducted on relatively small sections of the entire core.
2. The quantity of rock investigated by the neutron log is more comparable to that affecting the electrical logs than to the small "plugs" generally used in core analysis.

Despite its drawbacks, the comparison with core analysis has been used as extensively as possible. A considerable part of this work has been conducted independently by S. H. Rockwood,* who very early recognized the simplicity of correlation between porosity and neutron response. In order to be complete, it must also be mentioned that the same investigator has compared with great success many neutron derived porosities to porosities evaluated from cuttings.

Fig. 1 shows one of the first attempts to correlate neutron deflections with porosities computed from the MicroLaterolog (Well A — Permian Basin). Linear scales were used on both axes, but the shape of the average curve suggests a much better presentation: If a semi-log graph is used, with porosities in logarithmic coordinates and neutron deflections in arithmetic, the points will plot nearly on a straight line. This has been done on Fig. 2, where the same points have been plotted on semi-log paper.

Fig. 3 shows a similar diagram, but in this case the neutron deflections were plotted versus limestone sonde derived porosities. Fig. 4 shows a gamma ray-neutron log to which continuous records of core analyses have been added. Resulting neutron deflection versus core analyses porosity plot is shown on the same figure.

Methods of Calibration

An essential characteristic appears immediately on these plots. Extrapolated calibration curve meets the porosity axis on the 100 per cent porosity point. This property has been verified on a considerable number of cases.[a] Therefore, it is necessary to know only one point at the low porosity end of the semi-log line in order to have a complete calibration chart. The problem of finding this point is not a new one. A similar question arose when interpretation of limestone curve was first attempted.[2] Experience, based upon a very large number of ex-

*Shell Oil Company, Midland, Texas.

[a]This is purely coincidental, since, of course, extending the curve for porosity values in excess of about 40 per cent has no physical significance. The extrapolation, nevertheless, provides for a very convenient and simple calibration rule.

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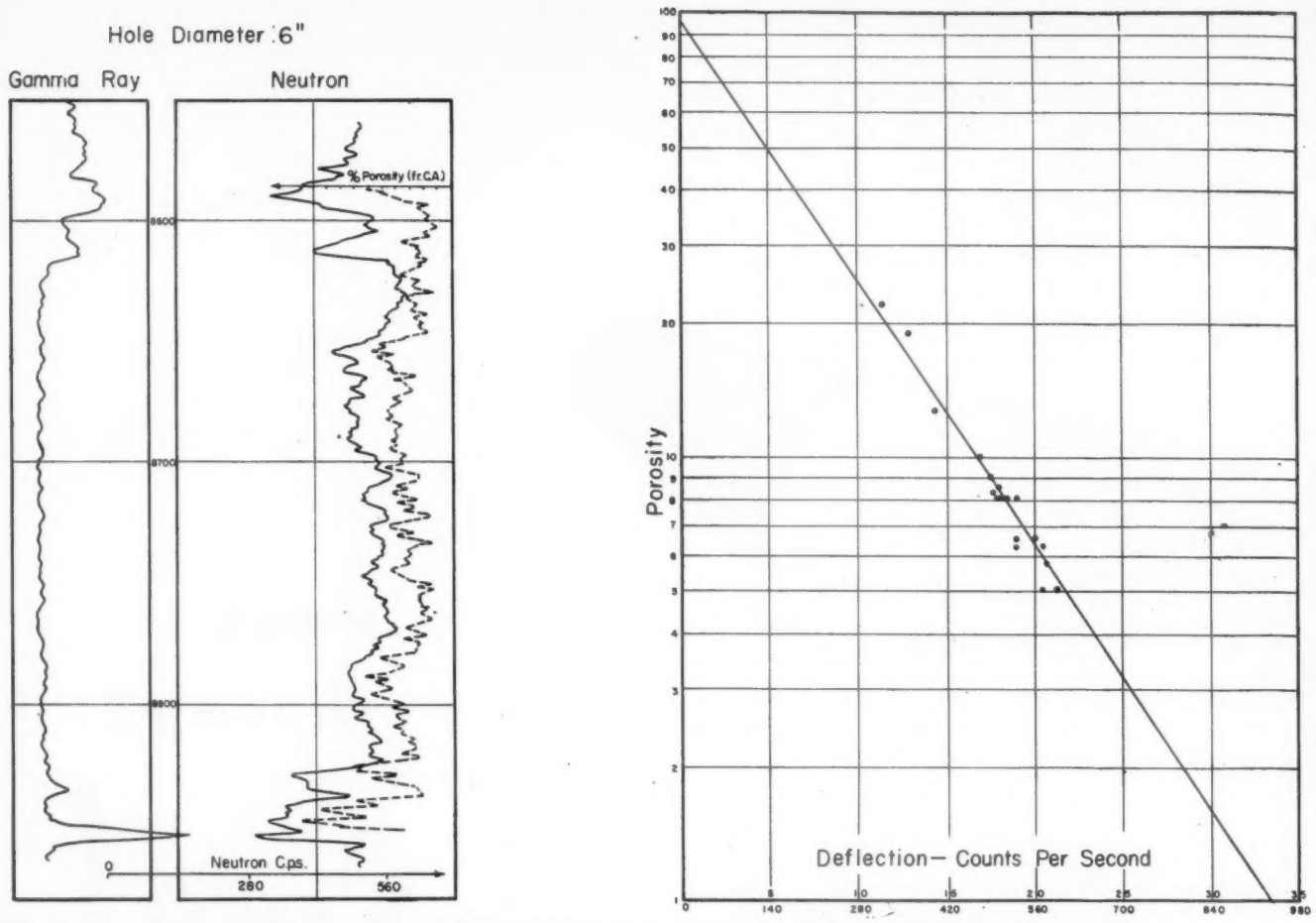


FIG. 4. Gamma ray-neutron log to which continuous records of core analysis have been added. To the right is shown a plot of neutron curve deflection versus care analysis porosity.

amples, has verified that in the Permian Basin the porosity of the tightest limestones can be evaluated at 1 per cent.[b] It was indeed logical to use this same value for neutron logging, hence, the first empirical method for porosity calibration:

On semi-log paper use the logarithmic coordinates for the porosity, the arithmetic coordinates for neutron deflection. The calibration curve is the straight line joining the point 100 per cent porosity —0 deflection to the point 1 per cent porosity—maximum deflection (Fig. 5).

All neutron deflections are read from the "neutron zero," which is shown on the log. Units in which these deflections are measured can be the log divisions, inches, or centimeters.

Mechanism of neutron logging is such that evidently it cannot distinguish between total and effective porosity. It cannot distinguish either between different types of porosity, and in particular, it will give a porosity value for shales. This value is probably quite reliable, despite the fact that it does not correspond to permeability. As in a given region and for a given geological horizon the shale porosity value is quite constant, it was thought at first that it could be used to determine a point of the porosity calibration line. Experience has shown this to be unreliable because of the cavings generally encountered in the shale sections. Each calibration chart is valid for one hole size only, and this size must be well determined at the level used as a base for the calibration. Furthermore, the accuracy of the calibration depends, obviously, on the linear distance on the chart between the point zero deflection—100 per cent porosity and the other point used to draw the line. In this respect, a point corresponding to 1 per cent porosity will be better than one corresponding to 20 to 40 per cent, the common shale porosity range.

The above considerations point out the restrictions that must be used when this first calibration method is applied. They can be summarized as follows:

(1) Neutron curve gives only the *total* porosity. It measures the effective porosities only in limestones or sandstones entirely free of shales. Fortunately, examination of the gamma ray curve will generally give a fair estimate of the shale content of a formation. (This first restriction is common to all neutron derived porosity methods.)

(2) The method applies only when the section logged is long enough to encompass at least one of the tightest limestones in the region.

(3) Hole conditions (open hole, cased, etc.) and hole diameter must be the same in the tight limestone interval and in the zones where the porosity determinations are made.

Universal Method

Some of the objections to the above method can be avoided when using a standard calibration of the neutron curve. The natural unit to use with a Geiger-Mueller counter is the "number of counts per second" which, over a very wide range, is exactly proportional to the number of gamma rays entering the counter. It is a relatively easy matter, using standard test sources, to calibrate all instruments in counts per second and, in this manner, results are comparable.

Thus, for a given set of conditions, a universal calibration chart can be established. Fig. 6 shows some preliminary results, obtained in uncased holes of diameter 8¾ in., 7⅞ in., and 6 in., respectively. The mud weight was 10 lb. and a correction should probably be made for a weight quite different from this value. Effect of mud weights and casings are now being investigated in order to establish charts similar to that of Fig. 6 for different conditions. For instance, results indicate that in the case of 7⅞ in. hole, introduction of a 5½ in. string of casing decreases the number of counts per second by 15 to 20 per cent.

Merits of this method are quite apparent. Its drawbacks are the number of charts necessary to account for all cases and the danger of its being applied on shaly formations. For the time being, and until a more extensive experience is gained, it is preferable, when possible,

[b]This is for pre-Permian formations only. For more recent deposits, and/or in other regions, a value of 2 per cent has sometimes been used. The choice of this value is, of course, a question of experience.

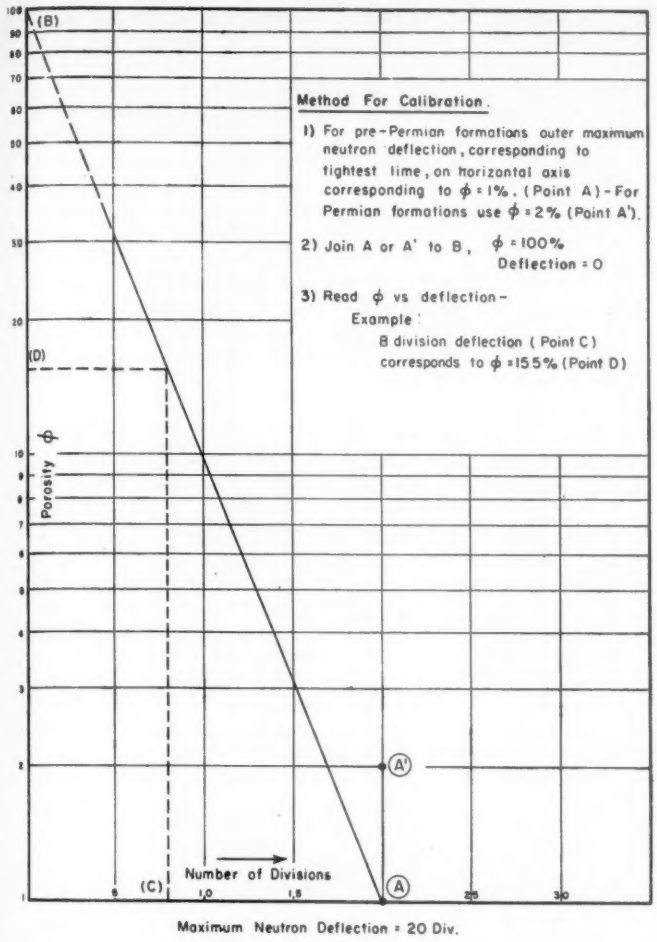

(B)
Method For Calibration.
1) For pre-Permian formations outer maximum neutron deflection, corresponding to tightest time, on horizontal axis corresponding to ϕ = 1%. (Point A) - For Permian formations use ϕ = 2% (Point A').
2) Join A or A' to B, ϕ = 100% Deflection = 0
3) Read ϕ vs deflection -
Example:
8 division deflection (Point C) corresponds to ϕ = 15.5% (Point D)
(D)
Porosity ϕ
(C)
Number of Divisions
(A')
(A)
Maximum Neutron Deflection = 20 Div.

FIG. 5. Neutron calibration curve shown is straight line joining point 100 per cent porosity—zero deflection to point 1 per cent porosity—maximum neutron deflection.

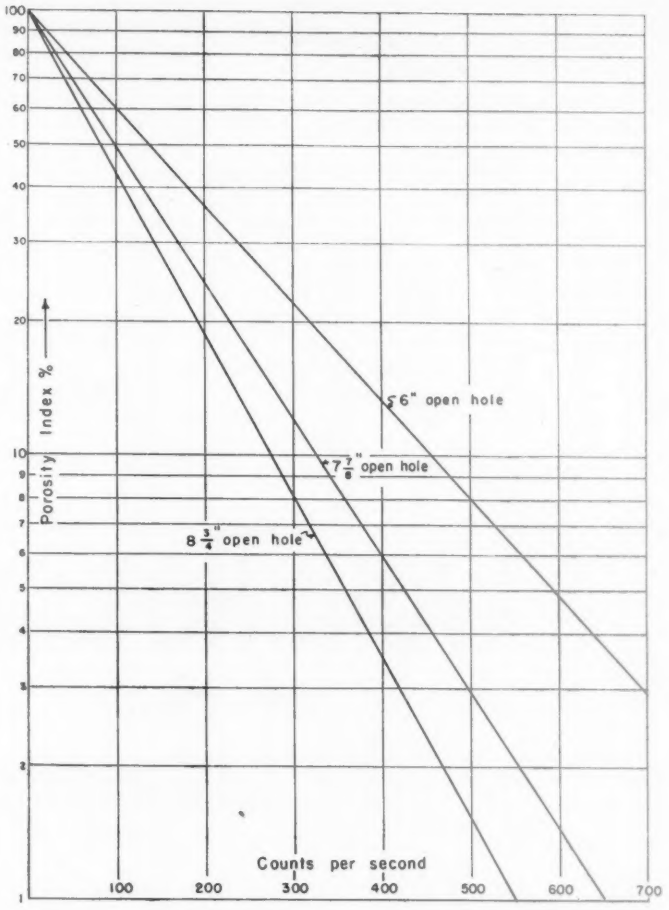
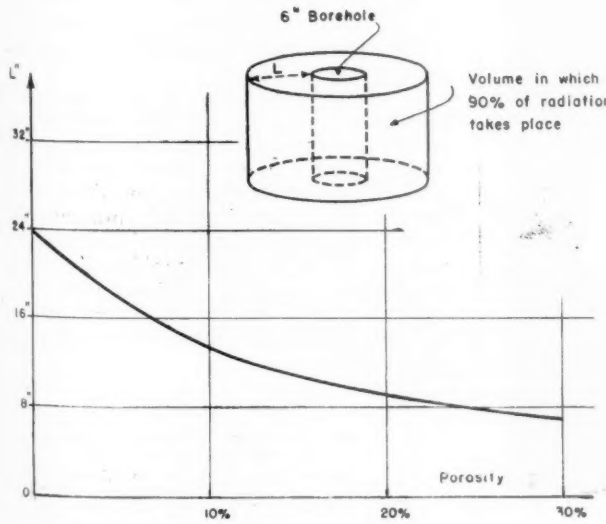
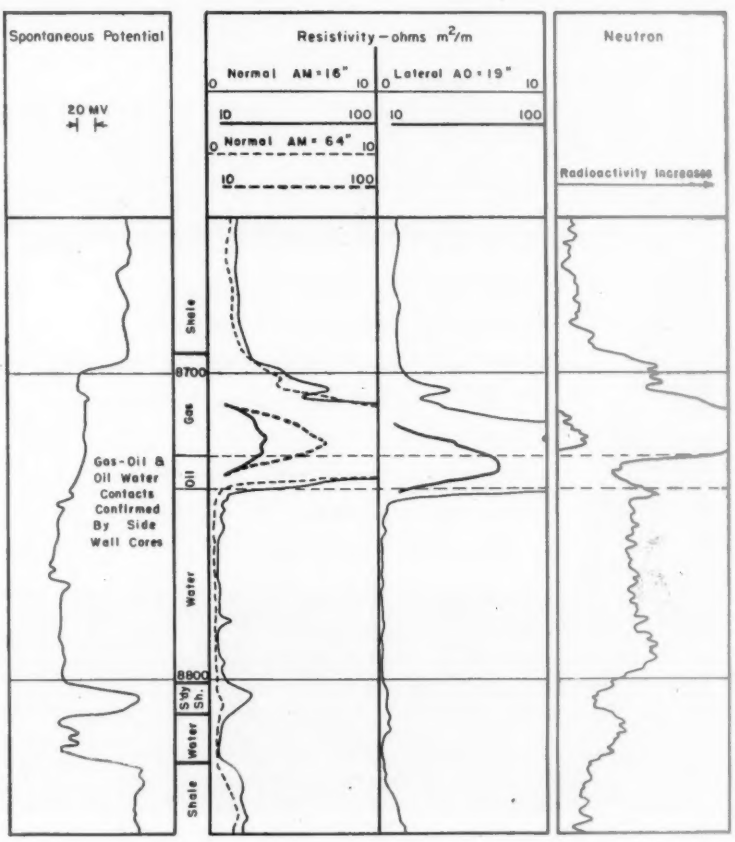


FIG. 6. Preliminary calibration results obtained in uncased holes of diameter 8¾ in., 7⅞ in., and 6 in.

FIG. 8. Right, a striking example of detection of gas by neutron logging.

FIG. 7. Below, relationship of depth of investigation of neutron curve versus porosity for all porosities from 0 to 30 per cent.





to use the first method which integrates all the data particular to each well.

Significance of Measurements—Sampling

It is interesting to have an idea of the amount of formation investigated by the neutron logging method.

1. *Vertical Investigation—Bed Thickness.* Laboratory measurements have shown that, provided the correct logging speed is used, there is no appreciable difference between the response of a bed infinitely thick and that of a 3 ft bed. A bed 2 ft thick gives 90 per cent of the total response. Consequently, in practice, it can be assumed that the neutron log averages the porosities in somewhat less than a 3 ft interval.

2. *Radial Investigation.* Considering now a thick bed, what is the radius of investigation of the tool? Theoretically at least, an enormous volume of formation plays a part in the total radiation, yet it is evident that the portions close to the bore hole will affect the response considerably more than those remotely situated. It was found convenient to compare the response given by a cylinder of given radius to that given by an infinite volume of the same substance. In particular, one can determine the radius necessary to give 90 per cent of the infinite volume response.

This work was done in the laboratory where it was found that this radius varies conversely with the porosity. For a 6 in. borehole, and for a non porous formation, 90 per cent of the radiation occurs within 24 in. beyond the bore hole, while for 30 per cent porosity this distance is reduced to 7 in. Fig. 7 shows this relationship for all porosities from 0 to 30 per cent. Evidently, for large porosities the radius of investigation is quite small.

The fact that the radius of investigation changes with the very parameter which is measured can indeed be considered as unfortunate. Yet, a similar difficulty is met in electrical logging where part of interpreter's art is precisely to estimate variations of investigation.

Special Cases—Detection of Gas

It has been stated above that the neutron log measures essentially the concentration in hydrogen, which in turn is related to the liquid filled porosity. If, on the other hand, the voids of a porous substance are filled with gas, and although hydrogen enters for a great part in the chemical composition of this gas, in a given volume of void there is less hydrogen than in the same volume filled with water or with oil. Consequently, the neutron log, in this case, will fail to indicate porosity.

Thus, if a formation is known to be porous (by core analysis, MicroLog. MicroLaterolog, etc.), and yet if the neutron log fails to indicate porosity, logical assumption is that it contains gas.

This detection of gas, at least in the light of present experience, appears possible only in favorable cases. The reservoir must be shale free and its porosity over the interval considered must be constant lest a change of porosity obscure the effect due to gas. Furthermore, the formation must not be deeply invaded by mud filrate because of the small radius of investigation of the neutron log in a porous medium. Such conditions are more likely to be encountered in sands of recent geological origin.

Fig. 8 illustrates a very striking example of detection of gas by neutron logging. In this case, discrimination is even possible between oil and water. Such possibility will probably remain rare because, to the favorable reservoir conditions mentioned above must be added the requirement that the oil gravity be such that it has a volumetric hydrogen content appreciably different from water.

It is conceivable that in the case of a gas sand, a good quantitative analysis of the content could be obtained by comparing the MicroLog or MicroLaterolog derived porosity to the neutron derived porosity. This possibility is presently under investigation. It is mentioned here only as one of the many problems challenging the petroluem engineer and to which a reliable and well calibrated neutron logging device offers the possibility of a solution.

References

1. H. G. Doll: The MicroLaterolog—*Journal of Petroleum Technology*—January 1953.
2. M. P. Tixier: Porosity Index in Limestone from Electrical Logs—*Oil and Gas Journal*—Vol. 50—Nos. 28 and 29—November 15, 1951.

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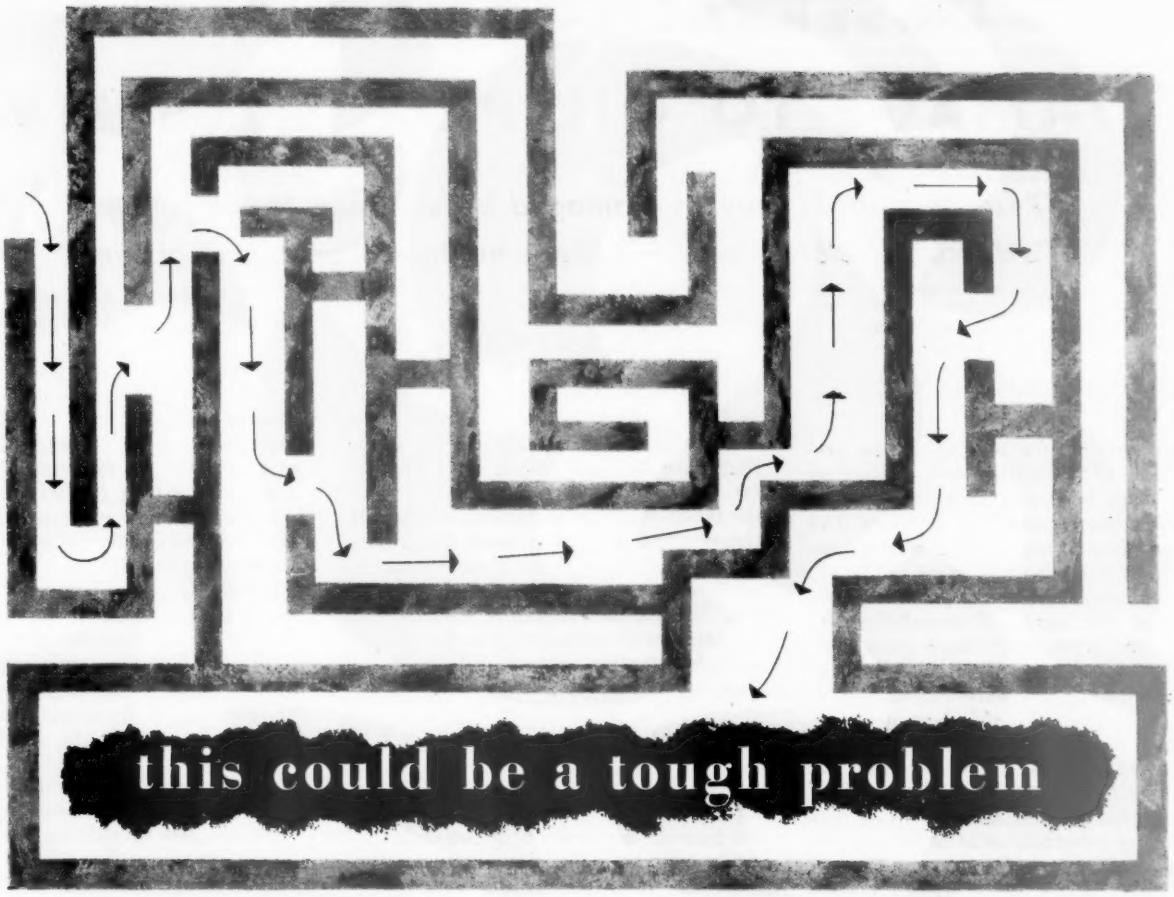

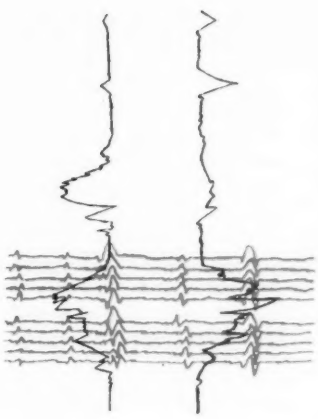

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OBSERVATION OF WATER DAMAGE TO OIL PRODUCTIVITY†

Reservoirs sands may be damaged by exposure to water, but it is difficult to relate extent of damage to physical properties of sands

T. A. BERTNESS*

Abstract

The possibilities of damage to productivity of oil sands by exposure to water have been indicated by well production histories and core analyses. The heterogeneous nature of oil sands, however, has made it difficult to relate the extent of water damage to physical properties of the sands. Permeabilities to brines and fresh water have often been used to indicate the susceptibility of oil sands to damage by water.

Laboratory and field data are presented that indicate that the flow of oil at moderate pressure gradients may restore effective oil permeabilities of damaged sands to values many times greater than the permeabilities of the sands saturated with water. Permanent damage to oil productivity, however, can be produced in sands whose structures are disturbed by invasion of water. Possible effects of water upon the permeabilities and structures of oil sands are discussed.

It is generally recognized that the productivity of many reservoir sands may be damaged by exposure of the sands to water. It has been difficult, however, to relate the extent of such damage to the physical properties of the sands. Core analyses have often included measurements of permeabilities to brines and fresh water, and these measurements have been regarded as indicative of flow behavior in the reservoir.

Oil sands thought to be susceptible to water damage have been described as water-sensitive, and water sensitivity has been measured by the reduction in water permeability which occurs when a sand containing reservoir water is exposed to fresh water.[1, 2a] Core analyses have shown that water sensitivity varies from zone to zone and in degree from almost complete reduction of water permeability to one of negligible effect. Few laboratory and field data, however, have been presented to show whether any correlation exists between water sensitivity thus measured and the effect of water upon oil productivity.

Purpose of this paper is to present laboratory and field data to aid in the evaluation of water damage to oil sands and to propose possible explanations for the types of damage to oil sands that have been observed. The particular problem which was investigated in the laboratory was to determine whether the permeability of a sand to various waters is related to its permeability to oil in the reservoir. The "reservoir waters" used in the laboratory studies were prepared with salinities matching those of the formation waters and the fresh water used was distilled water.

Discussion of Laboratory and Field Data

Cores from Field A. The cores selected for the first laboratory studies were from the Stevens zone which is composed of sands with a high clay content. The reservoir water permeabilities of these "dirty" sands are severely reduced if the sands are exposed to fresh water. The sands are, therefore, regarded as highly water sensitive.

Cores were prepared with oil and interstitial water contents believed to be representative of the saturations of the sands within the reservoir. The procedures used were the "restored state" or capillary pressure methods.[3] Capacities of the sands to conduct oil under these conditions were measured. These permeabilities represent the maximum effective oil permeabilities that would exist in the reservoir. The core samples were then flooded with fresh water and allowed to stand for 64 hours in contact with fresh water. Although the effective permeabilities to oil were low at first, it was found that the original capacity to conduct oil was restored within a day's time by flow of oil at pressure gradients across the cores below 12 psi per inch. Details of the tests are presented in Appendix A.

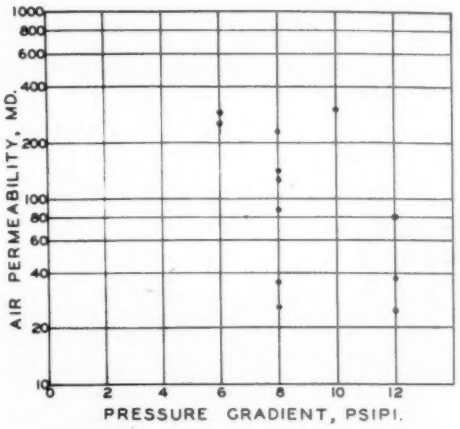

FIG. 1. FIELD A, pressure gradient to restore permeability to oil in fresh water damaged sands.

It is noted from the data presented in Fig. 1, that the sands examined exhibited varying degrees of resistance to the recovery of the original effective oil permeability. With the application of sufficient pressure gradient, however, the effective oil permeabilities of the water damaged sands were restored.

The studies of the sands of Field A were conducted with core samples whose original fluid content had been extracted in the laboratory. It was questioned whether the cleaning process had affected the sample's reaction to water. To answer this question an additional study was conducted with a group of oil base cores from the Stevens zone in Field B.

Cores from Field B. Samples of the oil base cores were prepared for study of flow behavior without cleaning and extracting the original liquids of the cores. The free gas present in the cores as received at the laboratory was substantially replaced by oil in the following manner: Propane was passed through the core samples to displace the gas present, and was followed by a flow of oil which absorbed the propane remaining in the cores. Core analyses of adjacent samples indicated that the water content of the oil-base cores as received in the laboratory was not disturbed by this process.

Effective oil permeabilities were measured, and a few pore volumes of fresh water were forced through the cores. Samples were then immersed in fresh water for a day's time. The effective oil permeabilities were again observed, and it was found that the flow of oil at moderate pressure differentials followed by capillary displacement with oil at 16 psi recovered an average of 85 per cent of the original effective oil permeabilities. (Appendix B, Table 3)

To check reliability of the initial measurements of effective oil permea-

†Presented at spring meeting of the Pacific Coast district, Division of Production, API, Los Angeles, June 2 and 3, 1953.

*General Petroleum Corporation.

[1]References at end of paper.

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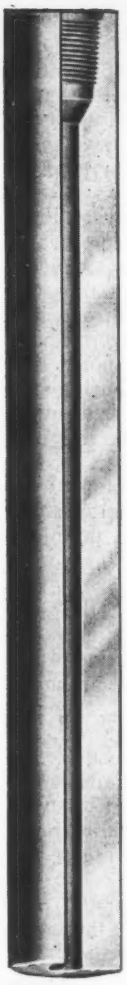

Bottom connection can be pin (above) or box (below).

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First

. . . in selecting the steel to be used in a Drill Collar, chemical specifications alone are not enough!

For example, simply specifying that a Drill Collar be made of a certain AISI specification steel—or any emergency substitute—permits far too great a variance of alloys to obtain uniform physical properties in the finished product.

Alloys that produce uniform properties when used in small cross-sections produce entirely different sub-surface properties when used in a thick-walled Drill Collar. Therefore, the steel used in Drill Collars should be selected by the "hardening characteristics" as well as by chemical specification.

Baash-Ross does this by checking the "End Quench Hardenability" index of each individual heat of specified steel to determine exact hardening characteristics. Then, based on this test, each heat of steel is separately classified as to the size of product cross section that particular steel is to be made into to secure the desired uniform physical properties in the finished product.

Thus, Baash-Ross assures each Drill Collar having accurately-controlled sub-surface as well as surface physical properties. Repeated re-cuts can be made on the threaded ends without sacrificing thread strength or hardness!

Second

. . . specifying that the Drill Collar should be heat-treated to a certain hardness is not enough!

The really important thing is *how* the Drill Collar is processed—how it is heat-treated to develop its best physical properties.

Through years of experience, Baash-Ross has learned that these processing steps are quite critical and must be accurately controlled to produce a Drill Collar free of structural defects and residual stresses. First, the bar is normalized and tempered over its entire length in one operation to produce a stress-free homogeneous structure with the desired physical properties.

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Thus, a Drill Collar is produced that is free from residual stress to assure sustained straightness—with high impact values to resist shock loading—and with the end zones of such uniform physical qualities as to permit repeated recutting without reduction of original joint strength!

Third

. . . specifying the size and type of joint desired on the Drill Collar is not enough!

Almost any machine shop can cut joints that will reflect proper gage standoff and will thread together. But the important thing is whether the joint is machined to obtain its full designed efficiency. Joints that are not produced with accurate thread form, lead and taper will permit wobble and cause failure. Furthermore, joint alignment in Drill Collars is particularly important because the rigidity of these members concentrates mis-alignment stresses on the threaded connections and is the most common cause of joint failure in Drill Collars.

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bilities, the cores were cleaned and saturated with interstitial water and oil by capillary displacement techniques. Oil permeabilities in the presence of interstitial water corresponded closely to the values obtained prior to cleaning the cores. The data obtained are presented in Appendix B, and indicate that the cleaning procedures employed did not affect the flow behavior of the cores.

Field C. With the development of a small field C over the past few years, considerable field and laboratory evidence have been obtained which indicates that satisfactory oil productivity can be established in water sensitive oil sands containing relatively fresh water. The salinity of the water native to the reservoir is approximately 125 gpg Cl^-. Permeabilities to water of this salinity were observed in the analysis of all core samples from the field, and the data obtained indicate that the productive intervals throughout the field generally have very low permeabilities to reservoir water.

Field evidence of this behavior was first obtained in a step-out well which cut the water table. The oil productive interval at this location appeared marginal and wet with possible oil production in the upper 15 ft: This interval was held open and numerous swabbing attempts were made over a period of two months. Only small amounts of water with a little oil were obtained, however. Eight days after the well was last swabbed to bottom, a depth-pressure test was run. The gage indicated that equilibrium static pressure had not yet been attained due to the extremely low gross productivity index. At this time productive wells in the remainder of the field were flowing 45 deg API oil from sands of similar permeability characteristics. At the edge well location the sands proved to be wet and to have a negligible productivity, however.

Numerous laboratory studies of the flow behavior to oil and water were conducted with core samples from the productive intervals of the field. Details of the tests are presented in Appendix C. Data from core analysis and the special studies indicate the following average properties of the zone open to production.

Permeabilities, md.			Interstitial water content per cent pore volume
To air	To oil with interstitial water	To reservoir water	
51	39	8	32

Calculations of completion effectiveness as described by Wade[4] were prepared for all the wells cored. The reservoir oil was initially undersaturated and produced with bottom hole pressures above the bubble point. Therefore, the effective oil permeabilities in the reservoir were assumed to be the same as those observed in the laboratory with interstitial water in place (by capillary pressure techniques). The completion effectiveness factors calculated in this manner ranged from 0.11 to 0.50 with an average of 0.27. These values are consistent with experienced oil productivity from sands of similar air permeabilities that are not water sensitive. Thus, field evidence indicates that a satisfactory oil productivity can be established in oil sands which have small or negligible permeabilities to water in the reservoir.

Field D. Production history of Field D has added further information regarding effect of water on the oil productivity of water sensitive oil sands. As water cuts developed in the production and bottom hole pressures dropped below the bubble point, it was noted that the measured productivities during subsurface pressure-flow rate tests dropped substantially below the observed productivities prior to these tests. It was concluded that when the pumps were pulled, water standing in the tubing was forced into the oil sands and produced an immediate detrimental effect on gross productivity.

Production rates following the subsurface pressure tests gradually increased to values produced prior to the water damage. Thus the water damage appeared to be only temporary. As reservoir pressures declined, however, the complete recovery of oil productivity became more difficult to obtain under the drawdown available to flow of oil from the reservoir. This behavior is illustrated by the production histories presented in Fig. 6.

The analysis of cores from the producing intervals indicated that the sands were sensitive to water. Furthermore, tests of the effect of fresh water on oil permeabilities showed that water damage could be overcome in time by the flow of oil under sufficient pressure gradient. Details of the field and laboratory data are presented in Appendix D.

Interpretation. The sands in each of the fields discussed above are well consolidated and contain clays which seriously affect their ability to conduct fresh water. A large portion of the productive oil sands of Field C appear to offer considerable resistance to the flow of the low salinity reservoir water. Yet the productivities of the wells in this field appear to be consistent with the average performance of clean oil sands of similar air permeabilities. The data presented for Fields A, B, and D indicate that effective oil permeabilities will be restored at moderate pressure gradients in water damaged oil sands that exhibit water sensitivity.

It is inferred that the restricted flow capacity to water displayed by these sands is due primarily to the fact that the fines and clays present in the porous structures are preferentially water wet. The silts and clays along the pore channels bond water normally associated with their hydrated structures. The amount of water held by clay and the degree of dispersion of the clay particles in water increase as salinity of the water is reduced. The dispersed particles within the water-filled pore channels move with the flow of water to positions which restrict water permeability. This behavior is indicated by permeability changes that occur when the direction of the flow of fresh water in water sensitive sands is reversed. An immediate increase in water permeability is noted with a change in direction of flow. With continued flow, however, the water permeabilities drop very rapidly to about the previous values.

The studies previously described show that oil permeabilities and saturations within the water flooded sands can be restored. It appears that with the application of sufficient pressure differential across the sand body, the oil-water interface can be forced through the larger pore channels. Water-wet particles do not pass through the oil-water interface into the oil and, therefore, are confined within the volume of interstitial water normally associated with the porous structure. The oil remains free of the water wet particles and flows through capillary channels lined with the water which surrounds the entire grain structure.

It was reasoned that if the above mechanism occurred, then a reversal of the flow behavior could be produced by conversion of the bentonites (water-wet clays) within the sands to bentones (oil-wet clays). Laboratory tests described in Appendix E were conducted to study this possibility. It was observed that dry oil permeabilities of cores were severely reduced by conversion of the clays to oil wet types. In addition, the conversion of clays within the sands to oil-wet types produced a marked increase in the capacity of the sands to conduct fresh water, as illustrated in Fig. 8. Thus it is concluded that the presence of particles within the porous structure of the sands can seriously interfere with the flow of a liquid which preferentially wets the surfaces of these particles.

Permeability of sands to reservoir water appears to be dependent upon the amount and distribution of reactive solids within the porous structure of the sands and the salinity of the reservoir water. Therefore, permeabilities to the reservoir water may not be indicative of the effective oil permeabilities in the reservoir.

All of the sands previously discussed were well consolidated, and though they exhibited extreme sensitivity to water, their consolidated structure was not destroyed by exposure to fresh water. Observations of flow behavior of thousands of cores during the past ten years have indicated that water sensitivity of reservoir sands may be brought about by many factors other than the behavior of clays lining pore channels of consolidated sands. These may be classified as follows:

a. Waters of various salinities may disturb cementing material and cause partial disintegration of the sand structure.

b. Clays may be present as lumps or streaks in sands and disturb the sand structure when contacted with water of various salinities.

c. Friable or semi-consolidated oil sands may contain large quantities of silts and fines which are water wet in the reservoir. The content of clays of

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TABLE 1. Flow behavior of Stevens zone sands, Field A.

Sample number	Permeabilities, md. To air, Ka	To oil, with interstitial water	To oil, directly after fresh water damage	Total hours of oil flow	Maximum pressure gradient psipi	Final oil permeability (Ko) md.
1	25	6.4	0.0	44	12	3.8
2	26	5.6	0.4	35	8	5.6
3	36	9.5	0.2	26	8	9.8
4	38	25	1.8	42	12	21
5	82	61	1.3	54	12	58.5
6	88	67	2.8	44	8	60
7	128	99	4.5	51	8	99
8	142	107	6.1	42	8	105
9	234	192	9.0	56	8	197
10	259	198	11.3	62	6	199
11	299	243	7.4	61	6	241
12	306	203	6.8	61	10	207

TABLE 2. Capillary pressure studies, Stevens zone cores, Field A.

Sample number	After displacement of brine with oil at a capillary pressure of 12 psi. Permeabilities, md. To air Ka	To oil with I.W. (Ko)	Interstitial water (I.W.) % pore volume	After displacement of brine by oil at 6 psi. Ko	I.W.	After displacement of fresh water by oil at capillary pressure of 6 psi. Ko	I.W.
1	25	5.9	42.4	4.8	51.1	5.6	47.7
2	26	7.0	36.9	4.6	48.3	7.0	45.0
3	36	13	39.0	10	49.1	15	46.4
4	38	21	42.8	23	46.6	23	46.3
5	82	61	33.3	58	35.9	59	38.1
6	88	69	33.3	68	36.6	70	34.6
7	128	99	29.7	86	35.3	99	31.6
8	142	104	30.7	98	35.4	107	34.9
9	234	185	26.7	180	30.8	188	27.6
10	259	196	26.4	200	28.6	198	29.0
11	299	229	23.1	229	28.5	226	28.9
12	306	198	29.8	197	32.1	200	28.8

TABLE 3. Behavior of oil-base cores prior to extraction.

Sample number	Permeabilities to oil, md. After propane	Following water damage. Initial	Ko (1)	Ko (2)	Ka md. (3)	Final saturations per cent pore volume. Oil (4)	Water (5)
1	11	0.3	4.6	13	26	53	47
2	5	0.2	0.7	3.5	10	42	51
3	58	0.5	51.0	58.0	84	61	38
4	2.5	0.2	0.7	2.0	6.5	45	43
5	3.3	0.2	0.9	2.4	6.7	47	52
6	3.7	0.4	2.3	2.7	8.7	46	51
7	5.2	0.9	3.9	4.6	14	46	50
8	10	1.0	6.8	8.5	16	51	46
9	6.4	0.7	4.6	7.0	14	57	43
10	7.5	0.3	3.6	5.7	14	53	47
11	7.1	0.4	3.3	4.3	14	47	49

(1) Effective permeability to oil after 18 hours of flow (11 hr at 4 psi, 5 hr at 8 psi, 2 hr at 12 psi, pressure gradient across cores, 1 in. diameter, 1¼ in. in length).
(2) Effective permeability to oil after capillary displacement at 16 psi for eight days.
(3) Air permeability of cores after extraction of oil and water listed in columns (4) and (5).

TABLE 4. Properties of cleaned cores with saturations restored by capillary displacement of water with oil at 16 psi.

Sample number	Permeabilities, md. To air	To oil with interstitial water	Final saturation per cent pore volume. Oil	Water
1	26	16	55	45
2	10	4.4	51	49
3	84	66	60	40
4	6.5	2.3	50	50
5	6.7	2.8	50	50
6	8.7	3.6	51	49
7	14	6.3	48	52
8	16	9.0	53	47
9	14	7.4	51	49
10	14	7.1	49	51
11	14	7.8	53	47

The synthetic reservoir water used in resaturating the core samples had a salinity of 1000 gpg chloride.

TABLE 5. Relationship of reservoir water and air permeability.

Per cent of core samples	Permeability to reservoir water
36	less than 0.1 md.
21	1 to 10 % of air permeability
30	10 to 50 % of air permeability
13	50 to 60 % of air permeability

swelling type may be negligible and differences in permeabilities to brine and fresh water may be small. Thus, the sands may not appear to be water sensitive. An increase of water saturation in such sands, however, may sharply reduce the gross productivity of the structure due to movement of particles with the flow of water. The flow of either brine or fresh water will harm such a sand structure.

Where invasion of water will alter the sand structure as in (a), (b), and (c), it cannot be expected that the flow of oil will regain the native productivity of the reservoir sand. In these instances the specific permeability of the sand structure is reduced, and the effective permeabilities to all fluids are reduced accordingly.

Conclusions

1. Water sensitivity does not directly indicate the effect of water on oil productivity.

2. The oil productivity of some consolidated water sensitive oil sands can be restored by flow of oil after invasion of water. The ability to overcome the water damage appears related to the drawdown available for the flow of oil.

3. The permeability to reservoir water may not be indicative of the effective oil permeability in the reservoir.

Reservoir water permeability should not be considered as a reference for relative permeability calculations. Instead, it is suggested that specific permeability or effective permeability to oil in the presence of interstitial water be regarded as reference values for relative permeability calculations.

Appendix A—Studies of Cores From Stevens Zone, Field A

Cores from the Stevens zone, Field A, were restored with oil and water content by capillary displacement at 16 psi. Cores were initially saturated with water of 1000 grain per gallon cloride salinity. The oil used was kerosine. After measurements of effective oil permeabilities in the presence of interstitial water were obtained, the samples were flooded with fresh water. The effect of water damage on oil permeabilities was then observed, and the data obtained are presented on Table 1. The effect of pressure gradient on the recovery of effective oil permeability is illustrated in Fig. 1.

The oil and water saturations and effective oil permeabilities were again observed on the cores following capillary displacement of salt water by oil at a pressure of 12 psi. The cores were resaturated with salt water and subjected to displacement by oil at a capillary pressure of 6 psi. The cores were again cleaned and then saturated with distilled water and placed in the capillary displacement cells as a pressure of 6 psi. Data obtained are presented in Table 2.

Appendix B—Studies of Cores From Stevens Zone, Field B

Appendix C—Studies of Flow Behavior of Cores From Field C

Core analysis of 173 samples of oil sands from the production interval (16 to 30 ft net oil sand) of 11 wells provided the following average properties of the zone.

Permeabilities, md. To air	To oil with interstitial water	To reservoir water	Interstitial water content per cent pore volume
51	39	8	32

Restored state studies were conducted with the cores initially saturated with synthetic reservoir water of chloride salinity (125 gpg), which approximates the salinity within the reservoir. Water was displaced from the cores with kerosine at a capillary pressure of 16 psi. The viscosity ratios of the oil and water

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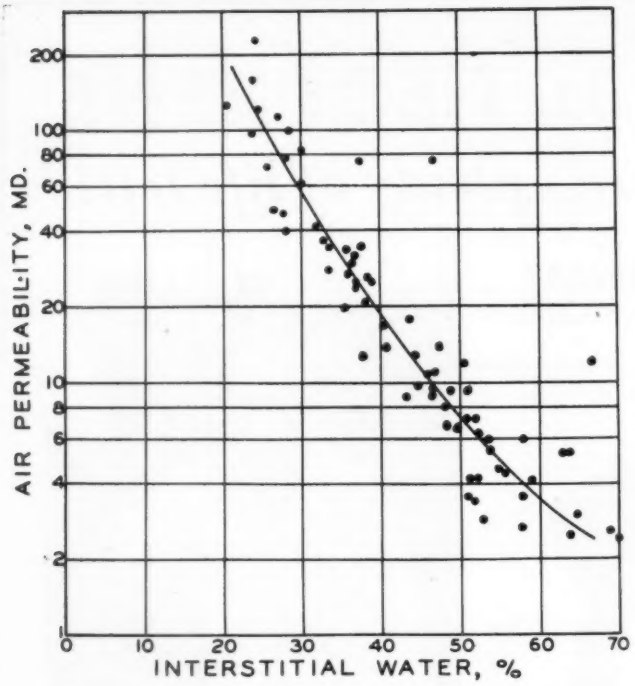


FIG. 2. FIELD C, interstitial water by capillary method.

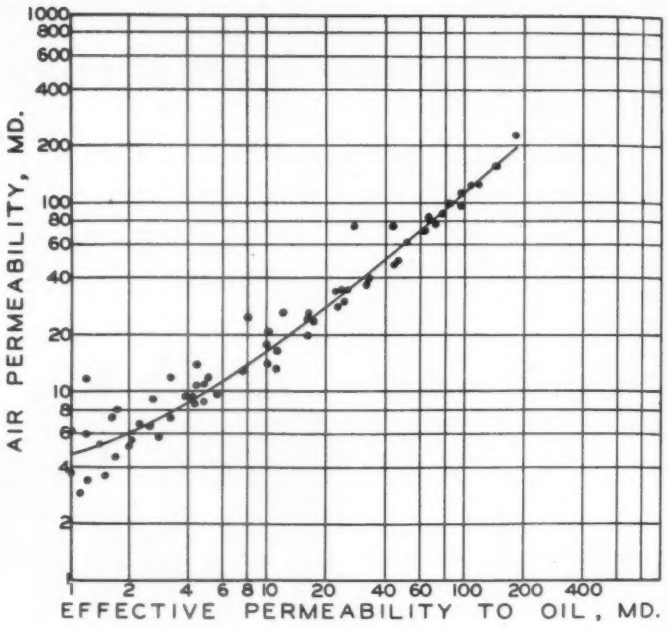


FIG. 3. FIELD C, effective permeability to oil in presence of interstitial water.

used in the laboratory approximated the viscosity ratios in the reservoir. The data obtained by these studies are presented in Figs. 2 and 3.

Studies of the effect of salinity upon water permeability gave the average behavior illustrated in Fig. 4. Permeabilities to synthetic reservoir water were measured on all cores. The data obtained are presented in Table 5. It is noted that the majority of the cores with high permeabilities to the reservoir water were from a relatively clean streak of sand found near the center of the field.

Lack of relationship between reservoir water permeabilities and the reservoir oil permeabilities is further illustrated by the data of Table 6 and Fig. 5. On the other hand, a reasonable relationship between air permeability and effective oil permeability in the presence

TABLE 6. Typical properties of oil sands from Field C.

Core sample number	1	2	3	4	5	6	7	8
Permeability to air, md. (Ka)	16	33	40	53	76	80	118	150
To oil in presence of interstitial water, md. (Ko)	8.9	17	29	32	27	74	112	117
To reservoir water, md. (Krw)	1.8	0.0	3.8	5.4	0.6	32	26	73
To fresh water, md. (Kw)	0.0	0.0	10.2	0.9	0.0	1.1	4.4	4.5
Porosity, per cent	23.7	20.1	20	20	24.2	19.8	19.4	22.9
Interstitial water, per cent pore volume, (I.W.)	39.0	33.9	33.3	31	46	26.3	20.3	23.5

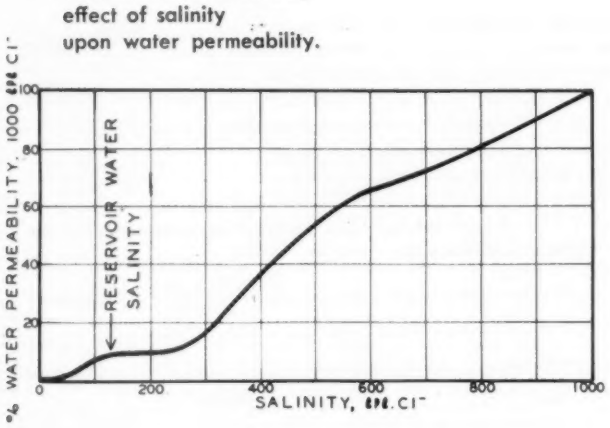
TABLE 7. Observations of productivity indexes inferred from production history and as calculated from well test data.

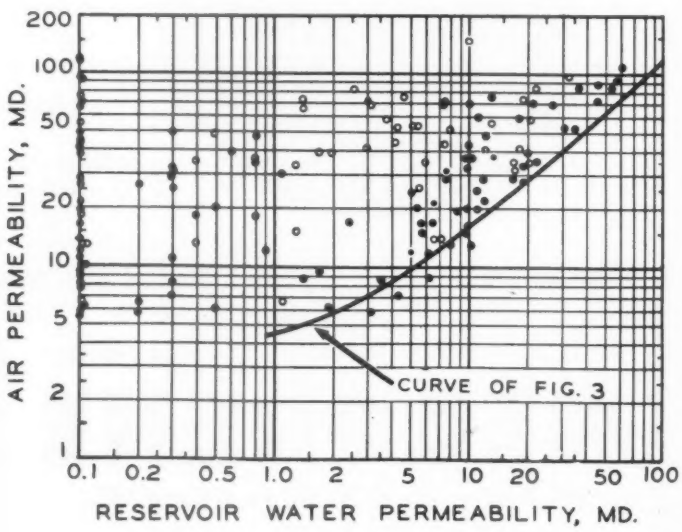
(The producing intervals were exposed to produced water immediately preceding well tests.) Wells were cutting 4 to 8 per cent.

		Test data		Inferred productivity index before test		
Date	Well	Rate during Test b/d	Observed P.I.	Rate Before test b/d	Producing pressure at pump	Inferred productivity index
1946	1	41	0.21	64	235	0.33
1947	1	11	0.05	14	100	0.28
1946	2	76	0.21	100	370	0.41
1947	2	21	0.12	92	210	0.80
1949	2	18	0.07	110	200	0.41
1946	3	70	0.23	92	370	0.40
1947	3	45	0.18	65	170	0.31
1948	3	31	0.15	67	300	0.59
1947	4	105	0.26	142	340	0.47
1948	4	87	0.20	120	320	0.37

FIG. 5. FIELD C, right, relation of air permeability to reservoir water permeability.

FIG. 4. FIELD C, below, effect of salinity upon water permeability.





• Cores from area near center of field. ° Cores from balance of field.

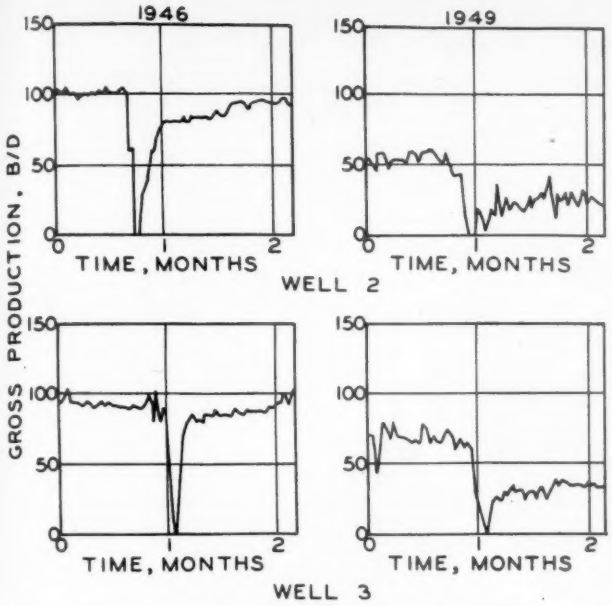
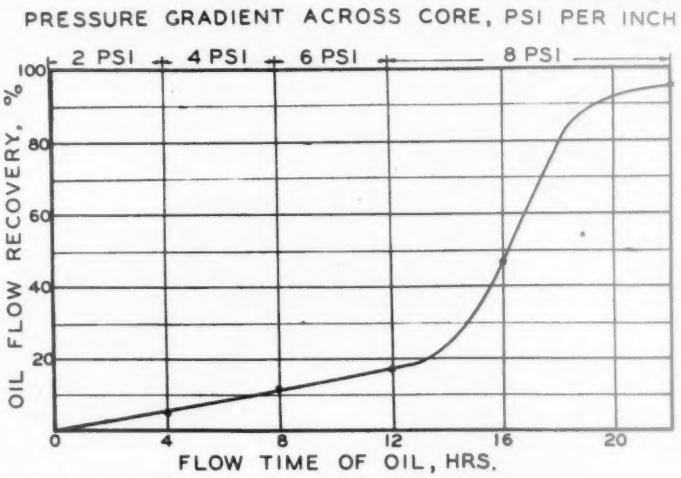


FIG. 6. FIELD D, left, production history of wells exposed to water in well bore.

FIG. 7. FIELD D, below, recovery of oil permeability after water damage.



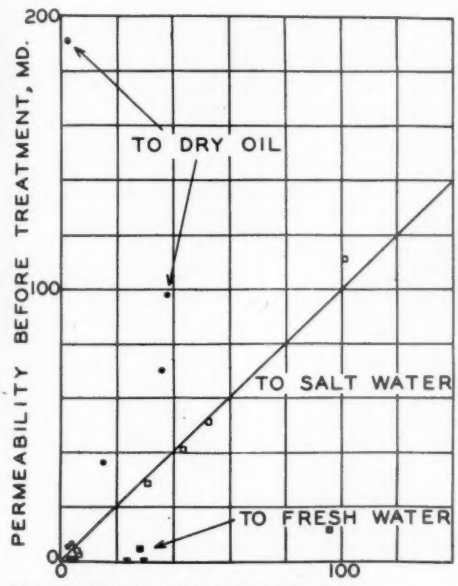


FIG. 8. Effect of water-wet and oil-wet surfaces in cores upon flow behavior.

TABLE 8. Laboratory studies of sands from Field D.

Sample number	1	2	3	4	5	6	7	8	9	10	11
Permeability, md.											
To air, Ka	50.0	29.4	20.8	9.90	19.3	41.0	7.45	13.8	42.0	43.0	50.5
To reservoir water, Krw	45.0	25.2	18.2	7.60	15.5	34.4	6.50	11.9	37.2	39.0	44.0
To fresh water, Kw	14.6	7.75	9.15	4.30	3.66	14.0	4.30	6.75	11.7	11.2	10.3
To oil with interstitial water, Ko	49.0	27.2	19.4	8.15	17.8	36.4	7.30	12.5	39.8	41.5	46.5
To flow of oil following damage by fresh water											
Ko, 2 psi, 4 hr	10.9	3.20	0.07	0.00	0.17	0.68	0.00	0.11	0.55	0.66	0.69
Ko, 4 psi, 4hr	15.8	6.25	0.36	0.03	0.71	3.08	0.18	0.37	2.50	4.05	2.34
Ko, 6 psi, 4 hr	17.6	8.70	0.69	0.20	2.04	4.45	0.61	0.65	6.35	6.35	4.25
Ko, 8 psi, 4 hr	26.0	14.5	2.48	1.29	8.90	9.85	2.32	2.68	25.6	23.4	24.6
Ko, 8 psi, 10 hr	43.5	27.0	18.1	7.50	16.6	35.2	7.45	11.6	37.2	41.0	45.5

TABLE 9. Effect of wetting properties upon flow behavior of water sensitive oil sands.

Sample number	1	2	3	4	5	6
Permeability, md.						
(a) To air, Ka	91.0	99.5	7.40	8.60	46.5	197
(b) To oil, Ko	70.0	98.0	5.45	6.40	36.6	191
(c) To reservoir water, Krw	41.0	51.5	3.10	3.68	29.6	136
(d) To fresh water, Kfw	0.17	0.13	0.10	0.10	5.45	11.7
Permeability after treatment with quaternary ammonium compounds, md.						
(e) To oil, Ko	36.2	37.8	2.82	3.86	15.4	1.88
(f) To reservoir water, Krw	44.0	53.0	6.95	6.00	31.4	126
(g) To fresh water, Kfw	23.8	30.8	3.70	4.70	29.2	96.0

of interstitial water is indicated by the data of Fig. 3.

Appendix D—Field and Laboratory Data of Field D

Production histories preceding and subsequent to well tests are presented in Fig. 6.

Laboratory data of the flow behavior of cores from the producing intervals of Field D are presented in Table 8. Cleaned core samples were saturated with a synthetic reservoir water of salinity 585 gpg Cl^-. Permeabilities were measured to the flow of synthetic reservoir water (K_{rw}) and to fresh water (K_w). The sands were dried and resaturated with the synthetic reservoir water. Oil was then placed in the core samples by capillary displacement at 16 psi. The effective oil permeabilities (K_o) were measured and the cores then invaded by fresh water. Observations of the recovery of oil permeability were then made. A plot of the average behavior of the effective oil permeabilities is presented in Fig. 7.

Appendix E—Studies of the Effects Upon Oil and Water Permeabilities Produced by the Conversion of Clays Within Water Sensitive Sands to Bentones

The data obtained in this study are presented in Table 9 and the procedures employed are as follows:

The cores were cleaned and dried and permeabilities to dry air and dry oil obtained (lines a and b, Table 9). The cores were recleaned, saturated with brine and permeabilities to brine and fresh water observed (lines c and d, Table 9). To convert the clays within the sand structure to oil-wet and oil-dispersible bentones, the tests were continued as follows:

Quaternary ammonium compounds were added to the fresh water; a few pore volumes were passed through the cores and the cores were allowed to stand saturated overnight. The cores were then dried by high vacuum at 110 F and resaturated with oil containing polar compounds (kerosine + 10% toluene). After standing overnight measurements were made of the oil permeabilities (line e, Table 9). Cores were then cleaned by flow of acetone and application of high vacuum. After resaturation to brine, permeabilities were again measured to brine followed by fresh water, (line f and g, Table 9). The permeability behavior of the sands before and after treatment with the quaternary ammonium compounds is illustrated in Fig. 8.

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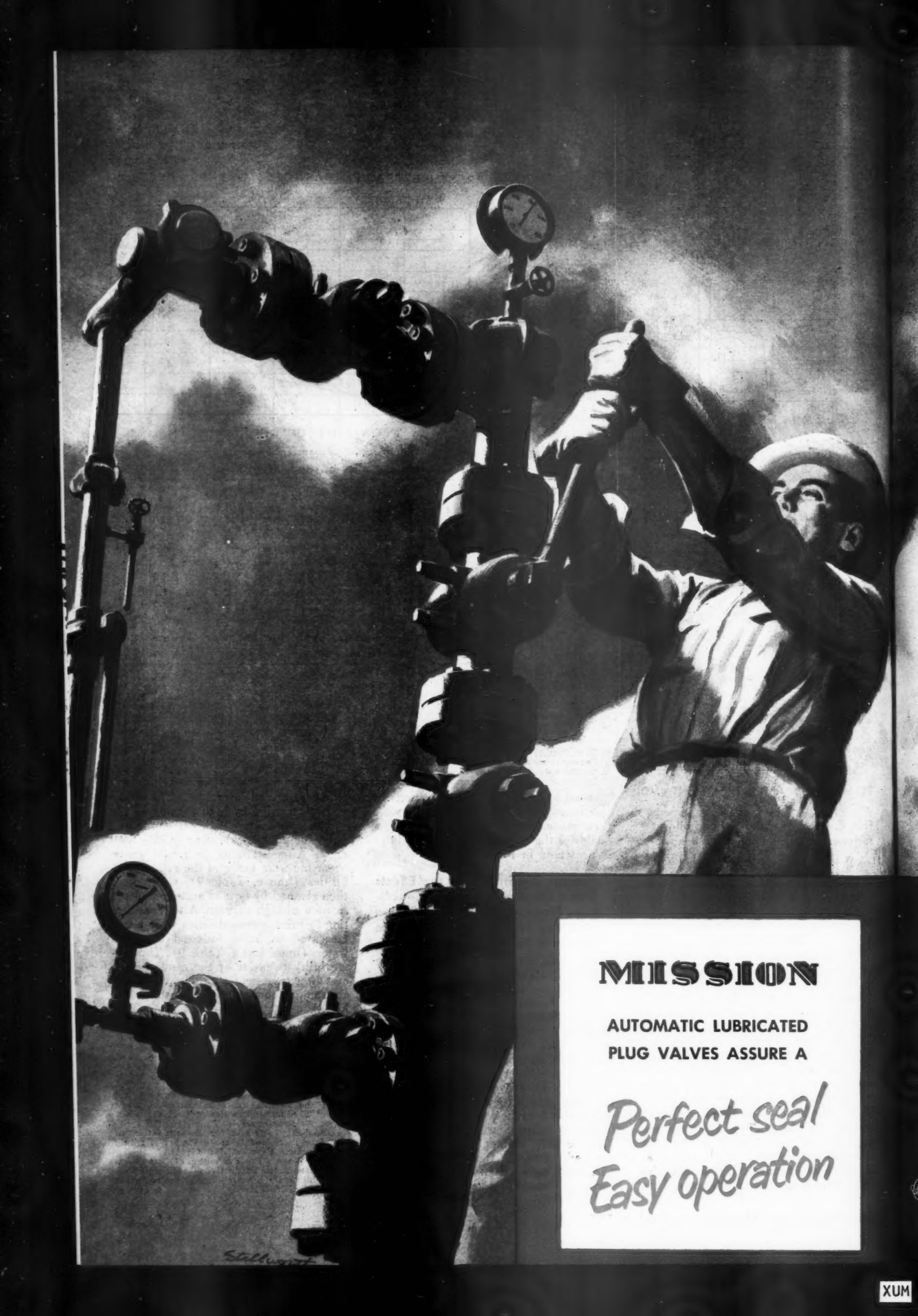
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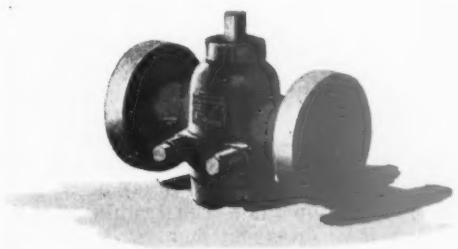

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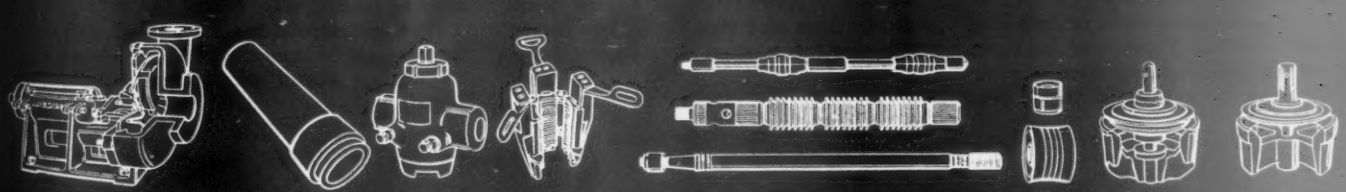

XUM

Tight Holes Are Poor Business

A more cooperative view on the release of well data will aid all operators in search for oil

JUST what well information should be kept "tight" and what should not and when should this data be released to the industry has long been controversial questions, yet many operators feel that certain principles and reasoning should be considered to govern the situation.

Few, if any operators can truthfully say they have given out more well information than they have received and although this article is not intended to criticize any individual or company, it will attempt to point out the possible damage of unwarranted "tight" holes to the future of the oil industry and to the operator himself.

An operator has several perfectly legitimate reasons to withhold information on a well. The first obviously is the fact that he has something to gain also that it is his money he is spending.

If the operator is drilling a wildcat on a block in which there is some open acreage, he is certainly justified in keeping certain information tight until it no longer serves his purpose. The economics of drilling the well may not warrant his leasing a solid block and he may choose to wait for confirmation of the anticipated structure or a show of oil before he is willing to undergo the expense of what might otherwise be unnecessary leasing.

The operator may also wish to withhold information on an oil show or structural position of a wildcat until he has exhausted efforts to purchase royalty or minerals in the area. No one would question the operator's right to do this.

Then there are often legal reasons for keeping a well "tight" for a certain period of time. Contractural obligations may require the well be started before all curative title work has been completed, or other questions of ownership have been settled to his satisfaction.

In some instances it is necessary to withhold information of geological importance because of differences of opinion as to the correct interpretation of the data. It is commendable that a company should wait until they know for certain and then report correct information where erroneous data could otherwise be responsible for serious mistakes being made.

In other cases, questionable data has been released with the full explanation of the dubious points. When "so-called" Cambrian production was first indicated in Coke County, Texas, for example, Humble Oil and Refining Company announced the discovery and stated that the oil may be coming from Cambrian formations, but also stated that the oil pay could be of a later age. The question was largely academic but it was beneficial to the industry to have the matter openly discussed for proper evaluation of its significance.

This paper was prepared at the instigation of The Petroleum Engineer in order to call to the attention of all operators the undesirable results that stem from the willful and malicious dissemination of inaccurate information or the withholding without reason of data secured through the drilling of wells. For perfectly obvious reasons, the authors have requested that their names not be published. This, while contrary to the policy of the magazine, will be the exception that proves the rule.—Ed.

On the other side of the question, there are numerous unfavorable results of a tight well and many of them could be avoided through proper cooperation and understanding between operator and scouts.

We are all familiar with tight hole areas and know that when the information is finally released, it is not always complete. In many instances the log has been lost or misplaced and coring and testing details are not complete. This often results in the information being lost to the industry for all times.

Exploration personnel who work an old tight hole area where only incomplete records may be available are forced to use "boiler house" or dubious information to fill in blank spots and this could mean an expenditure of thousands of dollars on a dry hole or that an oil field would not be discovered.

The operator who withholds well information after it can no longer be of value to him, should remember or take into consideration that his well was probably drilled on information made available to him from other operators. If this is true, it is only fair that he reciprocate with his information.

An unwarranted tight hole will often cause other operators to withhold information which they normally would release. In some scout checks, that operator's representative is barred from sitting in on meetings during the period that this information is being withheld.

EXCLUSIVE

Tight wells in some instances results in trusted employees "bootlegging" or selling information. The illegal sale or other divulgence of information on such wells is not only ethically deplorable and unwholesome, but causes unreliable well records.

This so-called "boiler house" or incomplete information has unknowingly been used in technical papers and by other sources, thereby innocently spreading false data throughout the industry.

For example, a well-known Albuquerque consulting geologist, recently published a report on a province of Northeast Arizona. Although certain parts of his paper were based on information made available to him through scouts, it turned out that their source apparently was not reliable. He stated in the article that certain wells in Conconio and Apache counties were bottomed in granite, but corrected information received after publication showed the wells to have been bottomed in the Pennsylvanian and Supai formations.

The author was unduly embarrassed and criticized, all because he had accepted information from the operator and scouts in good faith. The real danger of such a situation is when "boiler house" or incorrect information is recorded in the industry's files and is never corrected, thereby creating possibilities of costly mistakes.

The scouts do not expect the information to be handed them on a silver platter, but only ask cooperation of the operator in channeling the correct information through the scout's notebook, thence into their check meeting to become common property of the industry to serve as a sound foundation for all future exploratory efforts.

The operators have their responsibility in releasing accurate and complete information and the scouts have an equal important responsibility of recording the data correctly and training their members in swabbing complete data.

The oil industry is fortunate in having additional sources for information such as the commercial reports, newspapers and trade journals to keep its members informed as to all phases of this highly competitive enterprise that is the business of finding oil.

The commercial reports publish daily and weekly editions covering all oil producing areas and employ trained geologists, engineers and journalists to

XUM

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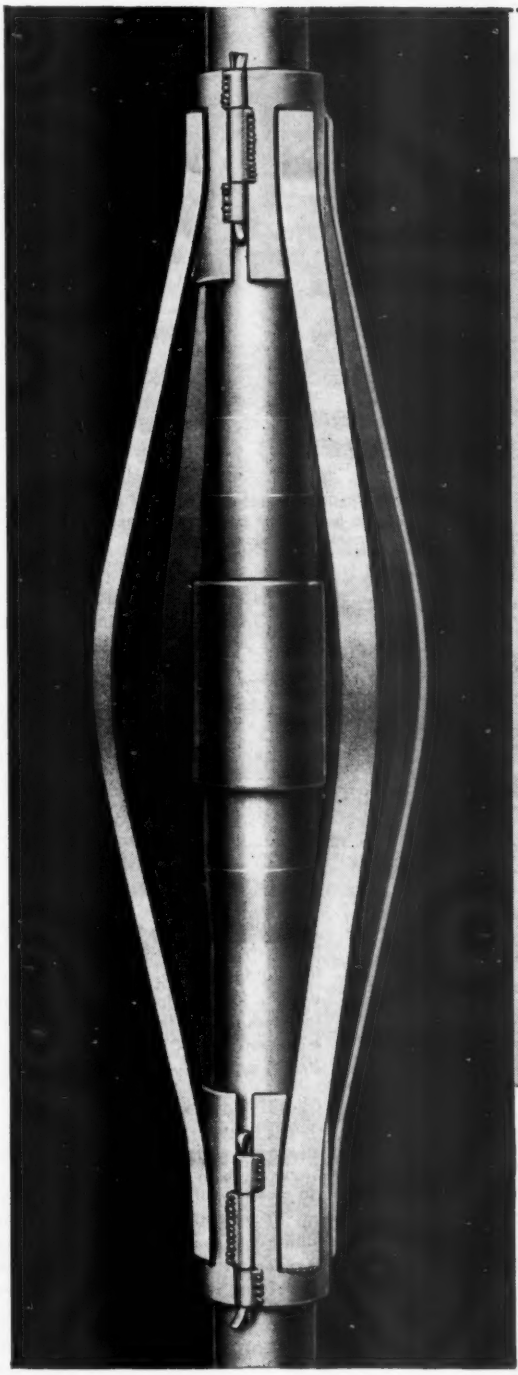

Here is a check list of nine good applications for Baker Hinge-Lok Tubing Centralizers. Undoubtedly you can add a few from your own experience.

- ☐ *For protecting couplings.*
- ☐ *For extending the life of tubing and casing by protecting it from excessive wear.*
- ☐ *For facilitating the running of tubing—especially in directional wells, where the sled-runner effect of the centralizer springs reduces the drag.*
- ☐ *For running on tubing above a Baker Retainer Production Packer to ensure proper centering, easier reentry of the tubing in the bore of the Packer, and elimination of any tendency of the tubing to bind in the Packer bore.*
- ☐ *For centering the tubing above a Baker Retainer Production Packer set between two zones to ensure that the tubing will not become sanded up in an extreme off-center position and thus to provide assurance that washing over can be accomplished without complications.*
- ☐ *For centering the tubing opposite the upper perforations of dual-zone completions to permit uniform entry of the fluid into the casing and to provide a protective cushion against the sandblasting action of the entering fluid.*
- ☐ *For cementing strings of tubing in gas-storage projects.*
- ☐ *For solving pumping problems in deep wells and in unusual pumping wells.*
- ☐ *For minimizing wear on pumping strings caused by the constant rubbing of the tubing against the bore of the casing as the tubing "breathes."*

When choosing tubing centralizers, remember that Baker Hinge-Lok Tubing Centralizers are:

Hinged for easy mounting.

Easily installed on either plain-end or external-upset tubing as it is being run.

Installed around a coupling. (The collars of the Tubing Centralizer are sufficiently large inside to permit them to slide over the ends of external upset tubing and bump against the coupling.)

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Product No. 9151, and state the nominal O.D. of the tubing string on which they are to be run.

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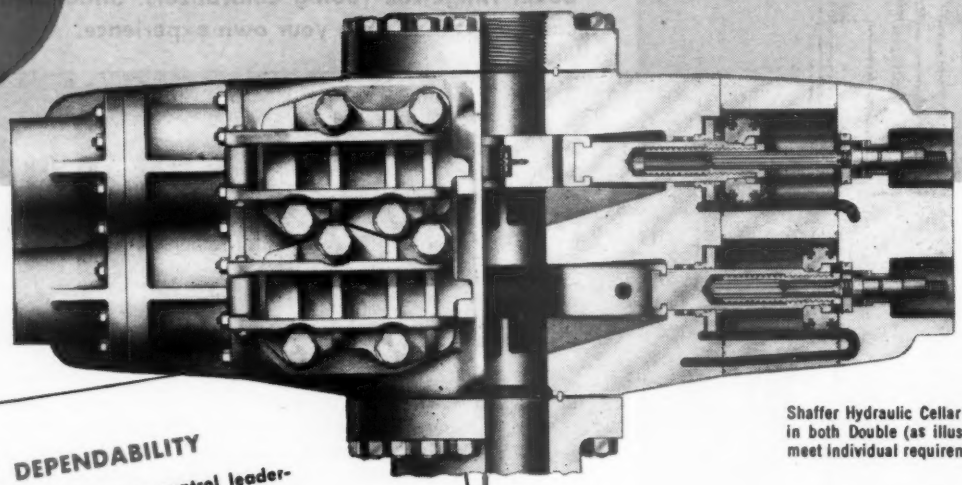
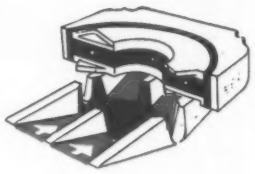


Shaffer Hydraulic Cellar Control Gates are available in both Double (as illustrated) and Single Types to meet individual requirements.

FIELD-PROVEN DEPENDABILITY

Backed by three decades of pressure control leadership, Shaffer Hydraulic Cellar Control Gates have proved their superiority under widely-varying field conditions. Successful from the first gate built, they have nevertheless gone through many stages of engineering, field tests and improvements and are accepted by operators everywhere throughout the world.



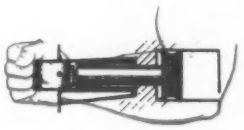
SELF-DRAINING COMPARTMENTS

The rams travel on narrow guide ribs high above the steeply sloped bottoms of the ram compartments. No detrimental mud or sand can accumulate — it quickly drains back into the well!

THREE-WAY COMPACTNESS

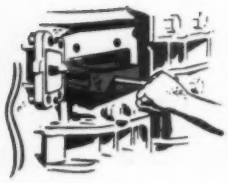
Even in sizes as large as 13⅝" (12" Series 900), Shaffer Hydraulic Double Cellar Control Gates provide *two* ram compartments unitized into *one* body in a total height of only 30".

And these gates are also unusually compact in length and width dimensions—*three-way* compactness that saves costly cellar space.



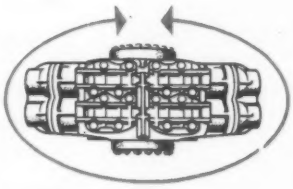
DIRECT HYDRAULIC DRIVE

There are no yokes — no complicated connections between rams and hydraulic cylinders. The operating pistons are *directly behind* the rams for positive fool-proof drive, fewer parts, and easy maintenance — insuring maximum simplicity, safety and dependability!



QUICK RAM CHANGES

Ram changes are quickly and easily made by merely opening side doors, replacing the rams and bolting the doors shut. *And complete ram changes can be made with equal ease whether the pipe is in or out of the hole!*



FULLY ENCLOSED DESIGN

No moving parts are exposed — nothing to become damaged by objects falling into the cellar, or corroded by chemical or salt mud drippings. Even the locking shaft is non-rising — completely enclosed and protected!

REMEMBER — Shaffer also manufactures a complete line of Double and Single *Mechanical* Cellar Control Gates for operators who prefer this type of equipment. And rams for both *Hydraulic* and *Mechanical* Cellar Control Gates are interchangeable, size for size, in most Shaffer Gates. This saves on inventory, simplifies maintenance where both types are used.

For full details see your nearest Shaffer representative — or write direct!

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check and report developments. One of the leading companies in the report field publishes on an average of 222,000 words daily and has representatives in all major oil centers with their offices linked together by a teletype network that enables them to flash "hot dope" throughout the country. These services are used by most of the major and independent companies and individuals to keep up with the fast pace of oil developments and add to information from their own sources.

Newspapers throughout the nation feature oil news and most papers in the Southwest and the Mid-Continent areas publish a daily oil page highlighting pertinent oil developments. Recently oil news has crowded out other front page stories in newspapers throughout Montana and the Dakotas.

The industry's trade journals and magazines, like the commercial reports, employ a selected staff of specialists and carry more advertisements and material than any other magazine now being published.

The National Oil Scouts and Landsmen's Association, in cooperation with its members, has for many years published a yearbook compiling oil statistics on the United States and Canada. This volume is recognized by the oil industry as one of their outstanding annual publications.

Several states are now considering proposed legislation that would compel operators to release well records through their agencies and to an industry that takes pride in its progress and cooperative policies, compulsory legislation should not be necessary. The best answer to this type of legislation would be for oil operators to release complete well records through oil channels.

When one considers the staggering total of 45,000 wells drilled each year, it is easy to see what a big task it is to gather this information in order to keep the oil finders informed. But with all the excellent facilities mentioned above, it is still the oil scout in the field with his leg work and long hours that furnishes the basic information for all oil reports.

The scouting profession dates back to the beginning of the oil industry and today there are approximately 1200 scouts reporting oil developments in 21 states. This represents an expenditure by the industry on its scouting program of well over $9,000,000 a year.

Toward what is the oil industry headed in respect to scouting? Is it to defeat the purposes of a questioning scout and take the attitude that because the operator is paying for a well the information gained by the drilling belongs only to him?

Such a nearsighted view is not tenable under normal conditions. Is cooperation with scouts in order to share and exchange information between operators and thus progress toward a better understanding of geology not preferable? Such a program would enable the scouts to create a storehouse or library of accurate and complete well information that would help all operators in their search for new oil. * * *

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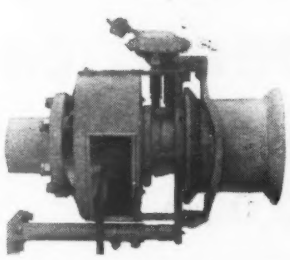
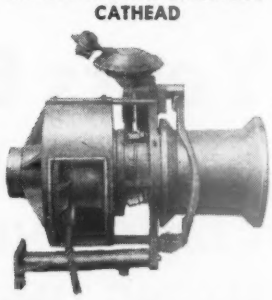


MIDGET MASTER BREAKOUT CATHEAD



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Carthage Field Compressor System

Operator installs economical system for the continued production of partially depleted gas wells in East Texas

C. A. BRASHEAR

THE Carthage gas field, situated in Panola County, Texas, and one of the major reserves of the state, now contains more than 600 producing gas wells. Successful completions have been made in the Glenn Rose, Hill, Upper Pettet, Lower Pettet, and Travis Peak horizons, with many of the completed wells being dualed from two of the above zones. Though the field primarily produces gas, there are a few oil wells concentrated generally in the southern part of the structure. Accumulations are controlled primarily by porosity development and few if any of the wells are productive in all zones. There has been little indication of any effective water drive and the producing mechanism for the field is primarily gas expansion. The majority of the wells are operated under exception to State Wide Rule 21 and deliver the total well stream to one of the six gasoline extraction plants operating in the field at a relatively high pressure. It became evident early in the life of the field that the comparatively rapid decline in reservoir pressure, which is normal for the existing type of producing mechanism, would force the installation of compressors to serve the lower pressured wells if they were to continue to deliver their prorated share of the field production.

The economics of such installations dictate that they be made early enough to prevent the offset drainage of the area served by the low pressure well yet not before they are actually required as they are inherently expensive both of installation and operation.

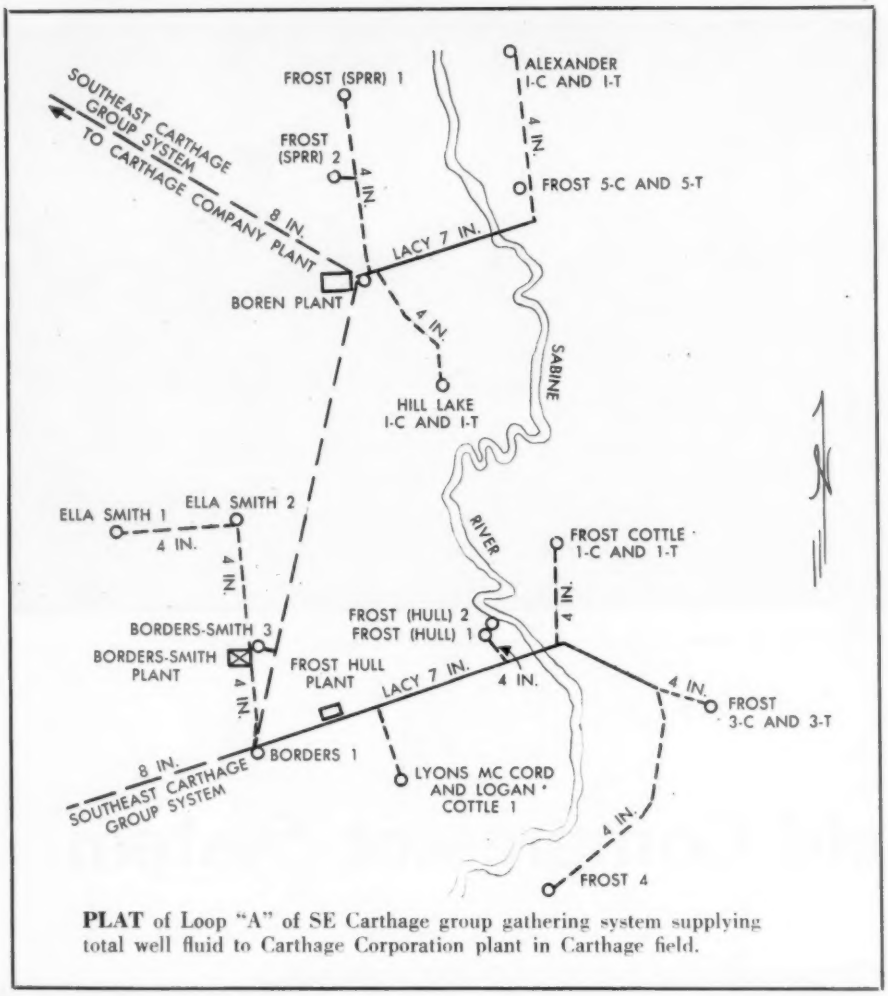
Prediction of Compressor Dates

The approximate date that compression will be required may be predicted through a close study of the producing history of the subject well. By plotting the bottom hole pressure record of the well against its cumulative production and then establishing the historical relationship between the cumulative production and time, it readily may be established that the well will be incapable of delivering its allowable against existing delivery pressures at some relatively definite date. This then is the target time for which the compressor must be planned. The selection of the proper size compressor is of course dependent on the discharge pressure required, the predicted suction pressure (this will in-

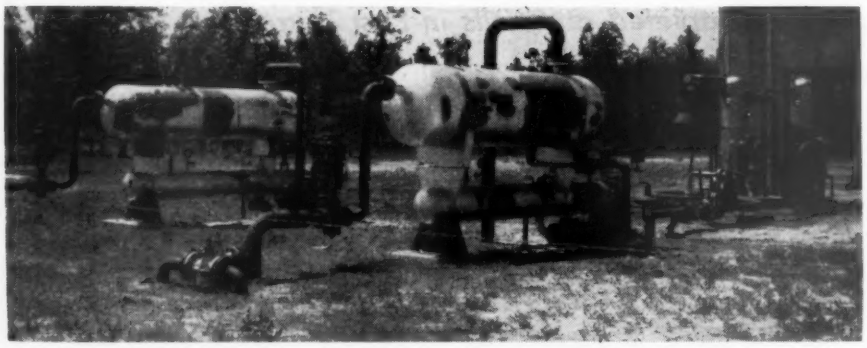
The Author

C. A. Brashear, member of the Roger Lacy, Inc., engineering department, in Longview, Texas, is in charge of gas production for the company. He joined Lacy in 1946 after five years service with the Armed Forces. Prior to his military service he had spent five years in seismic work for Seismic Explorations, Inc. of Houston, Texas, serving throughout the Southwest.

EXCLUSIVE



PLAT of Loop "A" of SE Carthage group gathering system supplying total well fluid to Carthage Corporation plant in Carthage field.



TWIN separator — fluid booster and suction gas scrubber used at Boren station.

volve the determination of the desired reservoir pressure at the time of abandonment of the well), and the anticipated delivery volumes. Fortunately, the design of most compressors permits their operation under a variety of conditions and frequently only a portion of the ultimate requirements of the station need be installed initially.

Early in 1952 it became apparent that some of the wells served by the Carthage Corporation plant would soon require the installation of compressors and a detailed study of the situation was made by representatives of the operators comprising the Southeast Carthage group. Under control of these operators, there were 61 wells, all producing into one jointly owned gathering system. From the results of the study it was immediately apparent that the estimated compressor dates were so widely at variance that a central plant serving all of the wells was not practical. It was seen, however, that a portion of the system, labeled Loop "A" on the plat, could remain as a high pressure line and that this portion could then be served effectively by a wide choice of smaller compressor plants properly situated and tied into the system by laterals. The decision having been made to utilize smaller stations instead of a central plant, operators proceeded with plans for their individual installations.

R. Lacy, Inc. System

Operator of 21 of the Southeast Carthage Group wells, R. Lacy, Inc., of Longview, Texas, was faced with the necessity of an early plant installation to continue the production of all of their wells. These 21 wells were so grouped that two 7-in. lines could serve 17 of them and the remaining 4 could be handled through a smaller compressor plant and a 4-in. line.

Estimated compressor dates for the wells were close enough together that, by properly locating the compressors, existing pipe lines could be used for the low pressure gathering system. This was particularly desirable because of the necessity for making several expensive river crossings in any system installed. It was further apparent that there would be three stations required, and that they would go into operation at about the same time. The properties were generally situated in the river bottom and subject to floods, so the selection of plant sites was complicated by both the desire to use as much of the existing facilities as possible and by the necessity of utilizing the highest ground available. Elevation surveys of all possible plant sites were made, and, basing the requirements on data obtained from water marks left by the highest flood on record, three sites were chosen that would be above water during a flood of similar proportions. Foundation soil analysis tests were then made and it was ascertained that the subsoil at the plant location was a very sandy loam. Using a very low loading factor and an ample safety factor, the compressor foundations were then designed and submitted to the manufacturer for approval and recommendations.

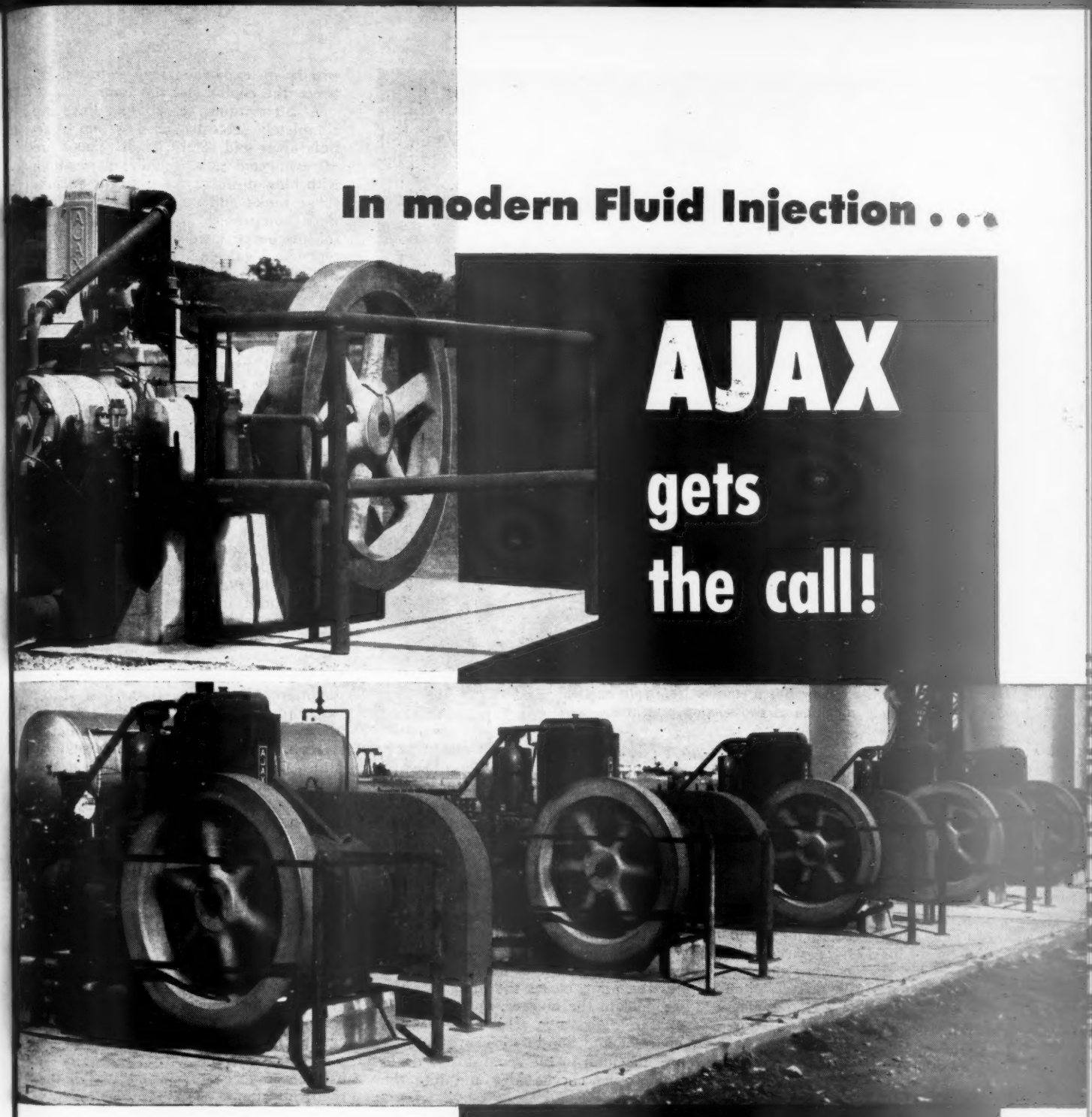
Compressor Selection

Selection of the compressors themselves offered considerably more problems. There was of course a definite job to be done and ample compressor power had to be installed to do this job, but excess horsepower was to be maintained at the lowest possible level. After much study it was decided that three units[1] would fulfill the initial requirements and could be converted and enlarged for any future requirements. In order to reduce the installation costs, they were purchased as skid mounted units.[2] When delivered to the location they were complete with suction and discharge headers, starting by-pass, radiator with oil and water cooling coils, and with ample capacity for the addition of gas intercooling coils, starting compressor, temperature and oil pressure safety switches, complete gas fuel system, and instrument panel. No additional piping or mechanical rigging was required to place these units in service, thus effecting a considerable saving in field installation labor. Each compressor cylinder is equipped with a clearance bottle connection to facilitate proper loading of the cylinder at the various suction and discharge pressures that are anticipated during the life of the project.

Station Design

The design of all three of the stations is basically similar. The produced well

[1]440 BHP Ingersoll-Rand 8-SVG.
[2]Purchased from J. B. Baird Company, Shreveport, Louisiana.



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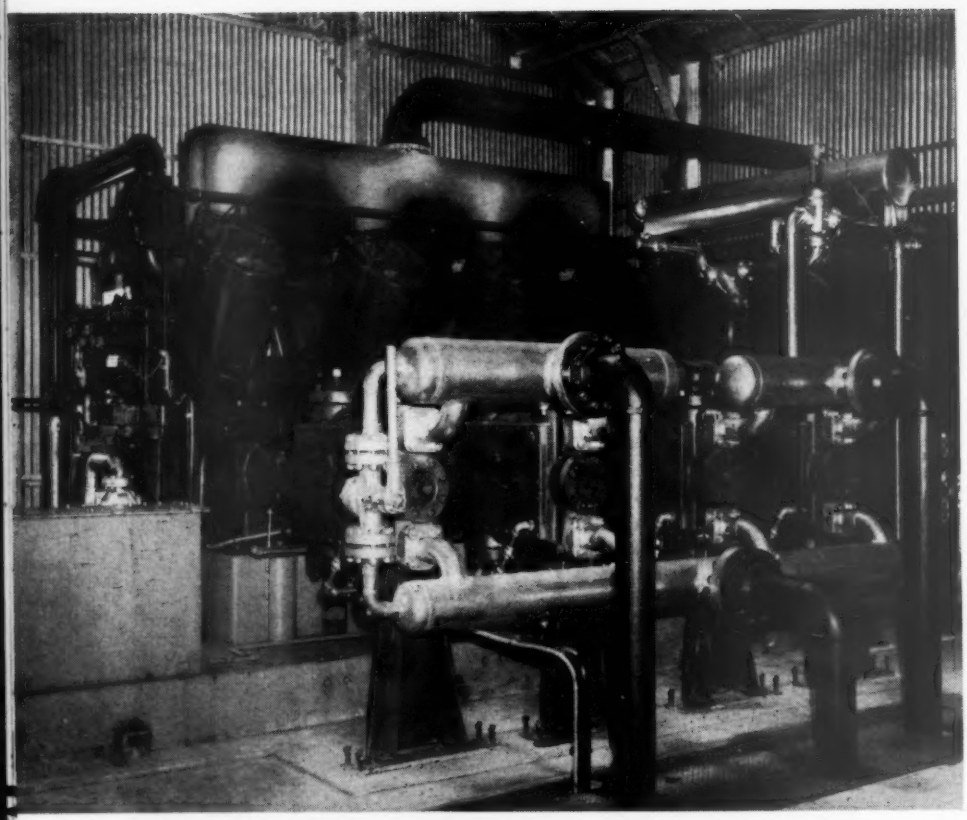


COMPRESSOR at Roger Lacy Boren station. Note split suction header permitting unit operation at two suction pressures.

fluid is conducted to the station site, passes through a reducing regulator and into a low pressure separator.[3] There the well fluids are removed and the gas is discharged through an inlet scrubber to the compressors. These scrubbers are equipped with mist extractors and high liquid level safety shutdown switches. Any fluid that may be carried over from the separator its trapped in the scrubber. Should the carry-over exceed the dump capacity of the scrubber and permit a fluid build up, the safety switch will ground the compressor engine magnetos and kill the compressor before they suffer from fluid damage.

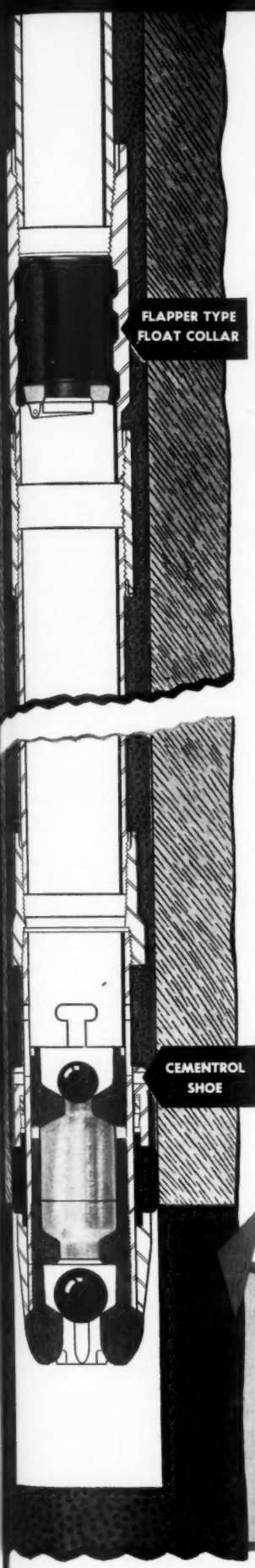
Well fluid from the separators is dumped into fluid boosters and from there is returned to the gas on the high pressure side of the compressors. The operation of these boosters is automatic and is actuated by the liquid level therein. As fluid from the separator enters the vessel, a float operates the pilot devices on two motor valves, closing the gas inlet valve from the low pressure separator and opening the gas inlet valve from the high pressure side of the compressors. This equalizes the pressure in the booster with that in the high pressure line and permits the fluid in the booster to drain into the line through a check valve. A block valve is placed in the compressor discharge line between the booster high pressure gas source and the booster fluid drain. The flow of fluid from the booster may be accelerated by slightly pinching this valve thus placing a small differential across the booster. This is particularly desirable when placing wells on the line because at that time they are apt to "unload" a considerable amount of fluid and may exceed the dumping capacity of the booster under strictly gravity drainage into the high pressure gas line. A check valve between the low pressure separator and the booster prevents the high pressure gas from backing into the separator while the booster is dumping. When the booster has completed it's dump, the liquid level float again actuates the pilot, closes the high pressure gas inlet to the booster, and opens the separator gas valve. This equalizes the separator and booster pressures and allows the fluid in the separator to drain through the check valve and into the booster.

As a further safety precaution, the low pressure separators are equipped with a second, or emergency, dump valve. As mentioned earlier, the wells have a tendency to "unload" when first placed on stream. If the produced fluid should exceed the dump capacity of the separator into the booster, or if the booster is too slow in dumping to the high pressure line, this second dump valve will open and relieve the separator to the pit, thus preventing a heavy carry-over to the compressor scrubber and possibly to the compressor. Expansion loops are currently installed in each high pressure gas discharge line between the compressor and the pipeline. In the multiple unit stations as they will eventually exist, the compressors will discharge through a loop and into a high pressure header. When the system is converted into stage compression, there will be an expansion loop required between the cooler and the units.

At all stations, vessels and lines are completely protected by a system of relief valves and safety heads. These are all connected to a common flare along with blow down valves from the various surge tanks and compressor cylinders. Each compressor is also connected to the discharge header through a piston type check valve and a block valve. This will permit isolating individual compressors in multiple unit stations without interferring with the operation of the other engines. Compressor engine fuel gas systems are very complete and designed to prevent any possible shutdown of the compressor due to fuel trouble. The primary source of the fuel gas is from the high pressure discharge side of the unit. A half inch high capacity non-freeze reducing regulator is installed in this discharge line and the primary fuel gas is taken at a reduced pressure to the first of three surge tanks. The fuel gas then goes through a second stage regulator and into a second surge tank. From this tank it passes through the fuel gas regulator provided with the unit, into a third tank mounted on the unit skids, and to the engine. An auxiliary supply of gas is taken from the compressor suction system behind the inlet scrubber, passes through a reducing regulator and into the first of the three fuel gas surge tanks mentioned above. This secondary supply regulator is set to operate only when there is a failure in the primary supply and the fuel system pressure falls below normal operating levels.

As is common in practically all field compressor installations of this type, the installed horsepower in the Lacy system exceeds the immediate requirements. The economical design of such a system requires a complete survey of the requirements through the ultimate depletion of the reserve. In this case, only requirements through single stage compression were considered and equipment adequate for this purpose was purchased. The plants are designed, however, so that all available power and all compressor cylinders will eventually be used in stage compression through the relatively simple change in headers and piping. Facilities for intercooling were provided in the purchase of the radiators wherein there is ample cooling capacity installed. The Boren station is serving four wells that have not quite reached their compressor dates and in the design of this station, the compressor suction header was split with two of the cylinders serving five of the lower pressured wells and the other two cylinders serving the four high pressure wells. This required the installation of an additional separator, booster, and suction gas scrubber and increased the initial installation cost for the station. The complete unit increases the flexibility of the station, however, and will effect an ultimate saving in horsepower and an increase in efficiency throughout the life of the project. Additional horsepower will be required at this station in the future and this was provided for in the

[3]National Tank Company.



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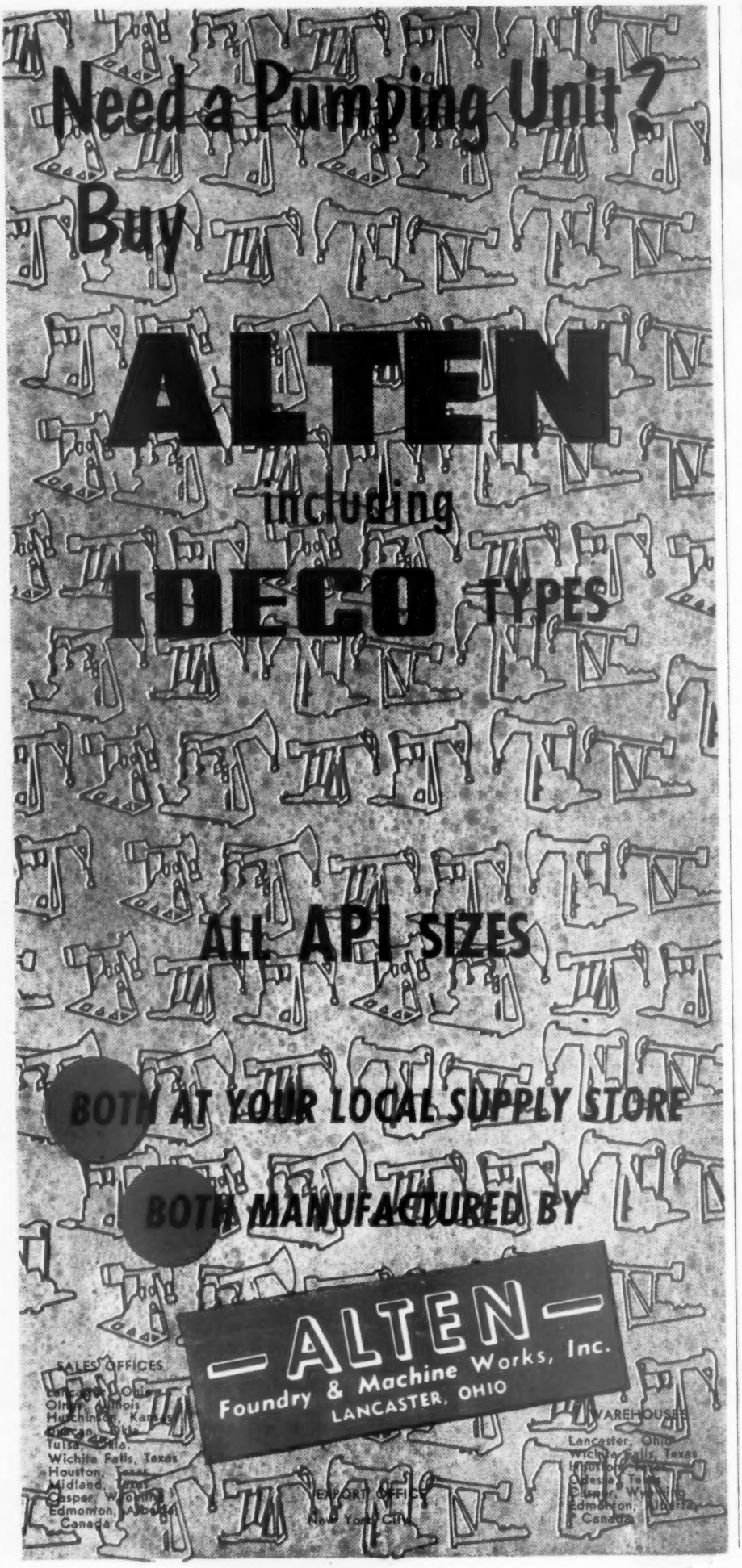

design of the station building and the foundation.

Prefabricated steel buildings are provided at all stations. These were selected of sufficient size to provide ample space for the starting air compressor, storage of oil and other supplies, and a small office. Past experience with heavy engines emphasized the need for a suitable means of handling heavy parts and all buildings are equipped with overhead cranes and hoists. The savings this equipment will effect in facilitating maintenance and repair operations will more than offset their cost without considering their multiple safety advantages.

Installed Costs

Plant installation costs in the Lacy system have been held to a low figure per installed horsepower due primarily to competent design and care exercised in the selection and installation of the equipment. All of the foundation work was done on a competitive bid basis with the operator providing all reinforcing steel and anchor bolts. The contractor provided sand, gravel, cement, forms, and labor, and poured compressor foundation blocks. station floors, and all outside pads for separators, boosters, and scrubbers, and other miscellaneous cement work. The erection of the steel buildings and the plant piping that was required was done on a force account basis under company supervision.

Each plant is equipped with the same size compressor but due to anticipated differences in the future requirements of each plant and to some construction differences caused by terrain, no two plants show the same cost per installed horsepower.

Lowest cost is shown at the Borders-Smith station. Here, the plant is complete and the addition of more power is not contemplated. There will eventually be some additional manifolding to do as the unit goes to stage compression but the expense anticipated is minor. Installed cost here was $205 per brake horsepower.

The Frost-Hull plant has larger outside piping, valves, and separator and facilities for additional piping to be tied into the common discharge and suction headers. No additional power is anticipated. Installed cost was $215 per brake horsepower.

A complete building sized to accomodate two 440 hp units was built at the Boren station. Also additional foundation cost was experienced due to the necessity of elevating the foundation 3 ft to obtain desired high water protection. The present compressor is equipped with a split suction and the station has dual separators, boosters, and scrubbers. Installed cost at this station was $235 per brake horsepower. * * *

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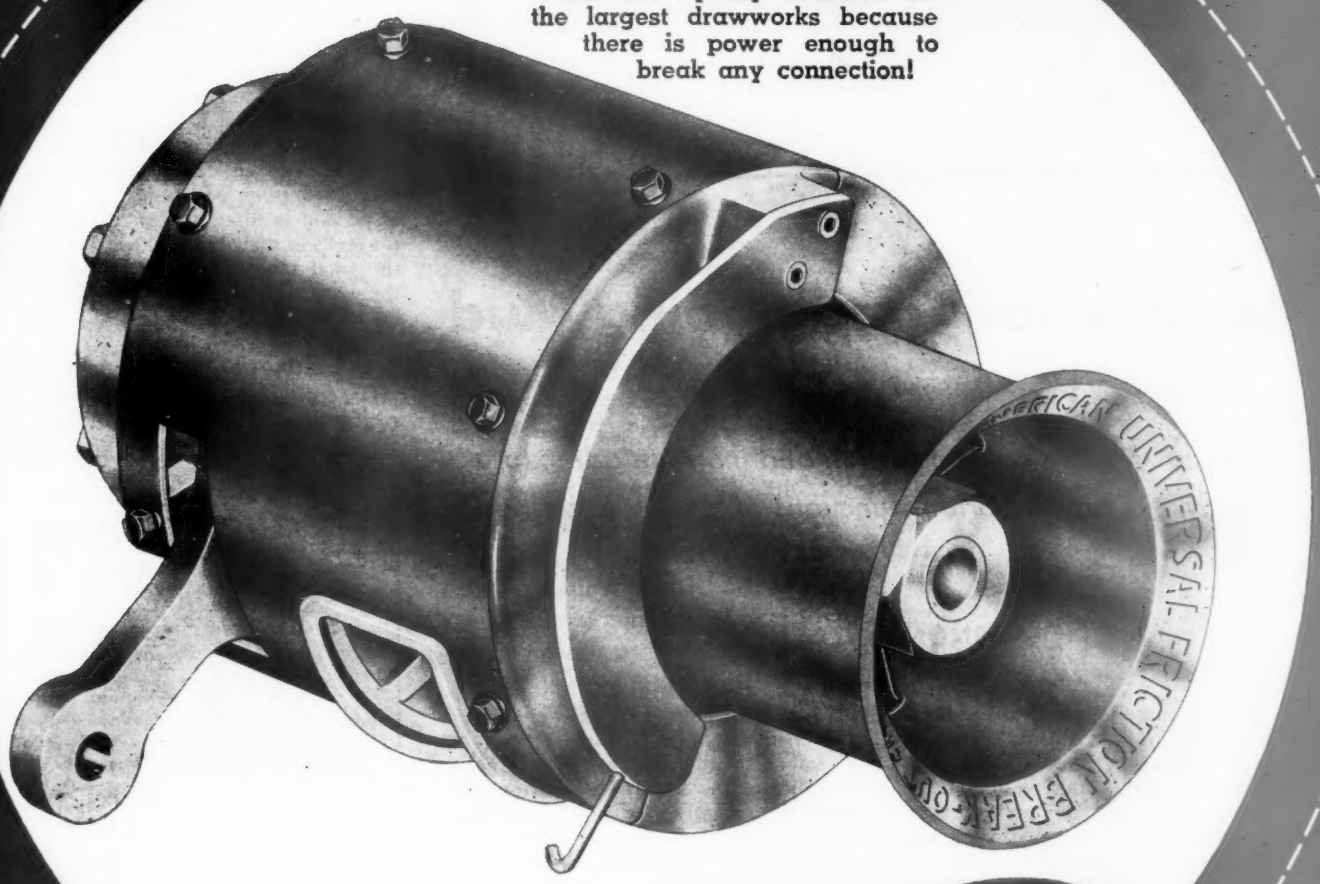

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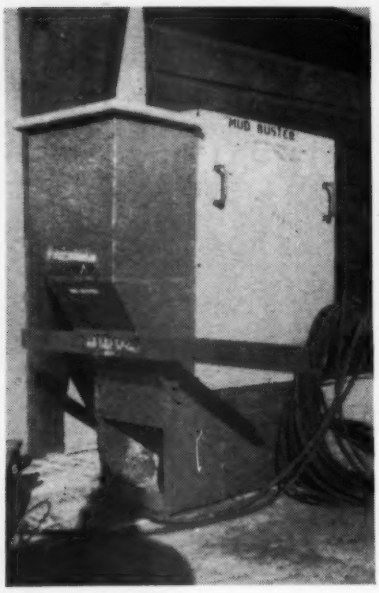
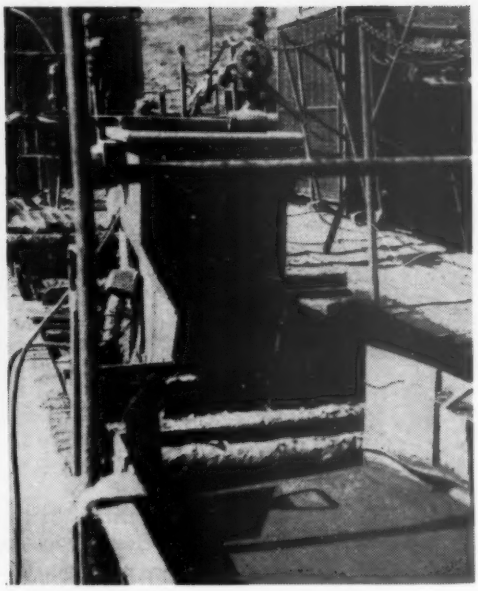


MOST recent version of machine awaits shipment to field.



MACHINE performs its several functions without interrupting mud circulation.

Machine for Conditioning Mud

Breakdown of extreme gellation and intimate admixture of reagents are important functions of device described

VERNON B. ZACHER

THE machine herein described has been nicknamed "The Mud Buster." To best detail its action one must consider the fundamentals of the mud system on a rotary rig. As is well known, all rigs, whether high-priced, deep-drilling units or those of the "bailing wire" variety, when drilling under modern concepts of scientific operation, are obliged to apply basic methods of mud circulation. These mud fundamentals are widely known and generally accepted but despite the most careful control of conditions, the required mud characteristics cannot always be maintained. There was a time when obvious changes in mud consistency and property were simply shrugged off as more or less inescapable but that is no longer true. Today it is the function of the mud engineer to make sure that the drilling fluid retains its predetermined qualities. Undesirable changes which take place are corrected with the absolute minimum of lost drilling time.

Two of the commoner mud circulating troubles are gellation and viscosity. Treatment of either one consumes time and chemicals, and frequently the lack of sufficient pumping capacity greatly complicates the situation. The time element in treating is a most important consideration since hours spent on one pump rig in mixing mud are lost drilling hours and it has been estimated that whenever mud is conditioned or mixed at the expense of halted circulation, the cost is at least $50 an hour and may be worth several hundred dollars an hour to many operators. In addition, there is always the danger of failure to recover circulation in a reasonable time and that, of course, can develop really serious and costly circumstances.

Much of this time wasting can be avoided through the use of the hopper because the machine eliminates the need of stopping circulation to adjust the character of the mud.

The usual causes of gelled highly viscous mud might be mentioned although they are familiar enough to most people concerned with the mud problem. They are: (1), The annulus through which returning mud flows goes beyond the size required for streamline flow at available rate of circulation. Because of its usual gellation characteristics, the mud is devoid of shear or internal movement and moves in a thick slug. Muds, in this manner, sometimes attain "toothpaste" consistencies. The gellation required to remove cuttings is much less than found in this extreme condition. Although most emulsion muds do not reach this advanced gellation stage, it can happen to any of them; (2), The mud contains improper and/or excessive solids; (3), The mud has been affected by reagents or impurities contained in formation or water; (4), The mud is chemically over treated; (5), The temperature of the mud is too high.

Actually, and although the above mud conditions are well recognized, their real significance is best appreciated by mud engineers, tool pushers, and drillers. They know what is likely to make trouble and they are constantly on the alert. Particularly they do not under estimate what occurs when conditions are unfavorable, and in consequence they become "symptom conscious." It is rational, of course, that just as the good doctor seeks to remedy the cause of sickness, the good mud engineer tries to correct the cause of mud trouble. Hence the "mud buster."

Basic Operations of the Machine

Generally, the operation originally contemplated for this machine was

The Author

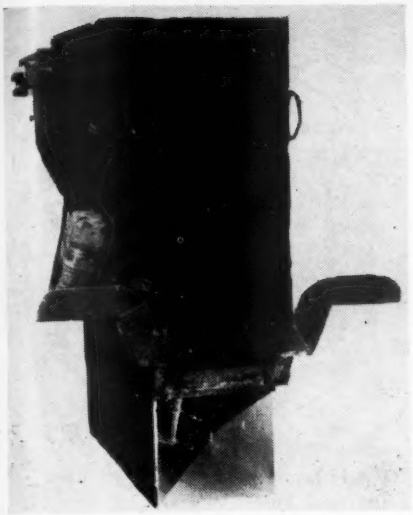
V. B. Zacher received his education at Montana State College, receiving a Bachelor of Science degree in 1923, and a Mechanical Engineering degree in 1928.

Previously he served with the United States Army. He entered the service as a private and at his time of discharge was separated as a First Lieutenant in the Infantry. During his time of enlistment he received the Distinguished Service Cross, the Purple Heart, the French Legion of Honor, and the Croix de Guerre with Palm. He began his career in the Army in the Mexican Border Campaign and served in World War I in England and France. While in France he was wounded in the Muese-Argonne battle.

After his service with the Army he worked for two years for Standard Oil Company in the engineering department, 1923-1925. He is now completing his 27th year with Tidewater Associated Oil Company, presently as superintendent of technical and research department of western division.

During his career in the petroleum industry he has invented the Zacher filter press and other aids for facilitating oil field mud engineering.

EXCLUSIVE



MUD BUSTER without its modern housing, shows angle of propellors in relation to hopper.

to deflocculate or reduce viscosity and gel strength of muds mechanically. The fact that its use was later extended to "chopping in" or quick blending of additives into muds came about quite naturally. This latter function is actually needed as the hopper mixing is not thorough and intimate mixing cannot be achieved in a single pass. The mud buster, however, does just that.

The machine has several functions and they are delineated here for the benefit of those who may be interested. Placement is a matter of importance although that ordinarily presents no great difficulty. Four specific uses are indicated, as follows:

1. As a mechanical mud thinner for high gel and viscosity treatment during ditch flow.
2. For circulating a mud tank or pit thoroughly while making round trips.
3. For blending in a single pass all chemicals, admixtures, or emulsifier materials into the mud stream whether circulating or not.
4. As a batch mixer of chemicals or other mud materials. (The ordinary chemical barrel or mixer is often inadequate for this purpose).

The mud buster (sometimes but not necessarily) utilizes an 8-bbl or larger tank. Mixture is almost instant and the mix or solution is added to the mud stream by gravitation or small pump. This task is simple since dry chemicals can be added rapidly. A tour batch of emulsifier lignite, lime, and caustic can be prepared as fast as the sacks can be opened. By the use of this device the pits are circulated thus eliminating the need for mud gunning yet effectively breaking gel strength. It is also to be noted that all clay, gel, weighting material and chemicals are put through the machine into the mud stream without shutting down circulation.

Applications to Various Muds

On the reduction of gel strength it is true that some gels, due to high solids, may not be reduced mechanically. Most gels, however, are definitely reduced by the mud buster. To be prepared to deal with the gel question one should divide the gel forms into four types:

1. Weak-fast gel
2. Weak-slow gel
3. Strong-fast gel
4. Strong-slow gel

The first two gels usually give little trouble as slight agitation breaks them. Both "fast" gels are usually acidic in character and will appear as lumps or "biscuits" in the ditch. Most of these fast gels are on the weak side. The most severe gel is the "strong-slow" type.

Much trouble is experienced with immoderate use of bentonite, although correct use of this material gets desired results. The impurities which will often cause excessive gel or flocculation are anhydride, gypsum, and the cement cutting calcium hydroxide. Other impurities, such as magnesium and sulfate in ionic form, give much trouble. The most efficient method of handling all impurities is, naturally, proper chemical treatment. Ordinarily, thickened mud will not absorb chemicals uniformly in solution. The remedy is to completely subject all particles of the mud to the chem-

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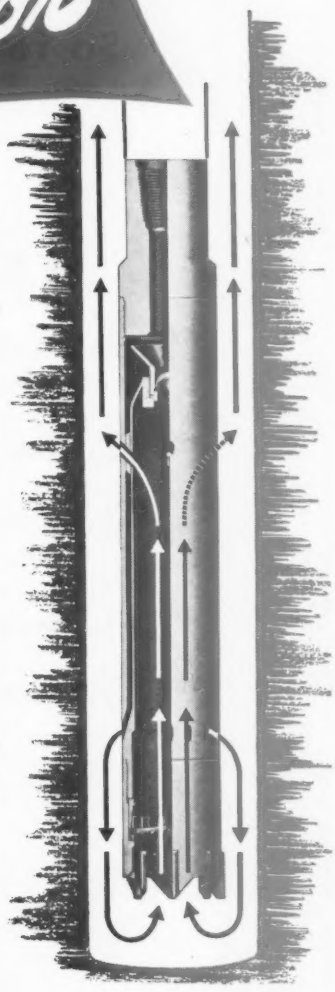

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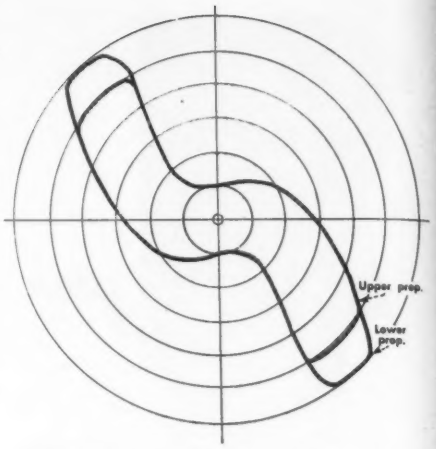
ical via the machine so that the result is immediate. The care history of several jobs shows that a very thick, plastic, cement cut mud can be thoroughly treated while passing through the mud buster. The mud, after proper treatment, emerges in a thin condition. Thus, mud usually discarded is saved. At a mud cost of $1.50 to $4.50 per barrel the savings usually on one job will be from $300 to $500 on mud alone, not counting the hours saved.

The use of the mud machine in blending admixtures with mud is important. Rotary clays, bentonites, weight materials, emulsifiers and lost circulation fibers are mixed efficiently. As the round trip may require a heavy batch for a "pill," the material is strung in directly. Also, as often happens, the job will be a "sweetening" up of the mud with gel, clay, weight, or other materials. This stringing in is done from the hopper, an integral part of the mud buster. As pointed out, mixture is complete upon passing through the machine. To better understand this performance a short resumé of the design follows.

Patent and Design Features of Mud Conditioner

Patented features comprise mostly the positioning of the chopping blades in the mud ditch or the mud circulating system with the multiple blade arrangement. The purpose is to "chop and throw," which is essential to the adequate performance of the machine. Only by a chopping speed of 3000 rpm, which represents a linear speed of 80 ft per second (at blade tip), can the machine function properly. The tungsten carbide, hard faced propellers are worn out in about 300 hours. The horsepower absorbed is about two, at 3000 rpm. This is to emphasize that although the machine is not large, it had to be strong and rugged.



ROUGH layout of the propellors used in the mud buster.

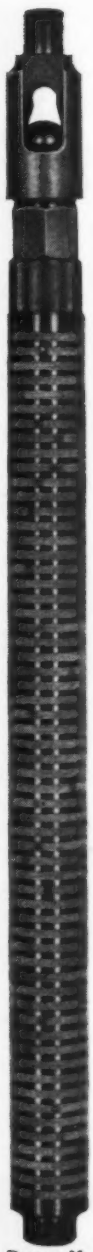
Design features were improved so that some very persistent bugs in the original machines were eliminated. The worst problem was that of sealing off a fast moving shaft against the usually abrasive mud. It took many trial and error experiments to finally conclude that it was the wrong concept entirely. Then, instead of a shaft rotating in a housing, the design was altered to have the housing itself rotate around a spindle. In this design mud cannot possibly enter the bearings. This spindle is 2¼ inches in diameter with a 4 inch diameter main roller bearing mounted at the pressure position. This is where the belt sheave is machined into the rotating housing. The rotating housing is operated in an oil bath. The motor is a 2 hp, 3440 rpm, fully enclosed, fan cooled type, operating at 220/440 v, 3 phase.

The propeller design had to be such that the chopping speed is constant from hub to blade tip. This required a special shape due to the difference of linear speeds (feet per minute) from hub to tip. The propellers will handle any mud or fibrous material without damage. Guards provide protection to hands or tools from the propellers. Propellers pull mud from the bottom of ditch, thus avoiding blending, or occluding air, into the mud stream.

Ordinary service requirements of the mud conditioner will be V belt and propeller replacements.

One precaution should be followed. That is to keep both propellers immersed in mud at all times while running. In some instances, when direct ditch installation is used, it is necessary to provide a dam to raise the level of the mud 12 in.

* * *



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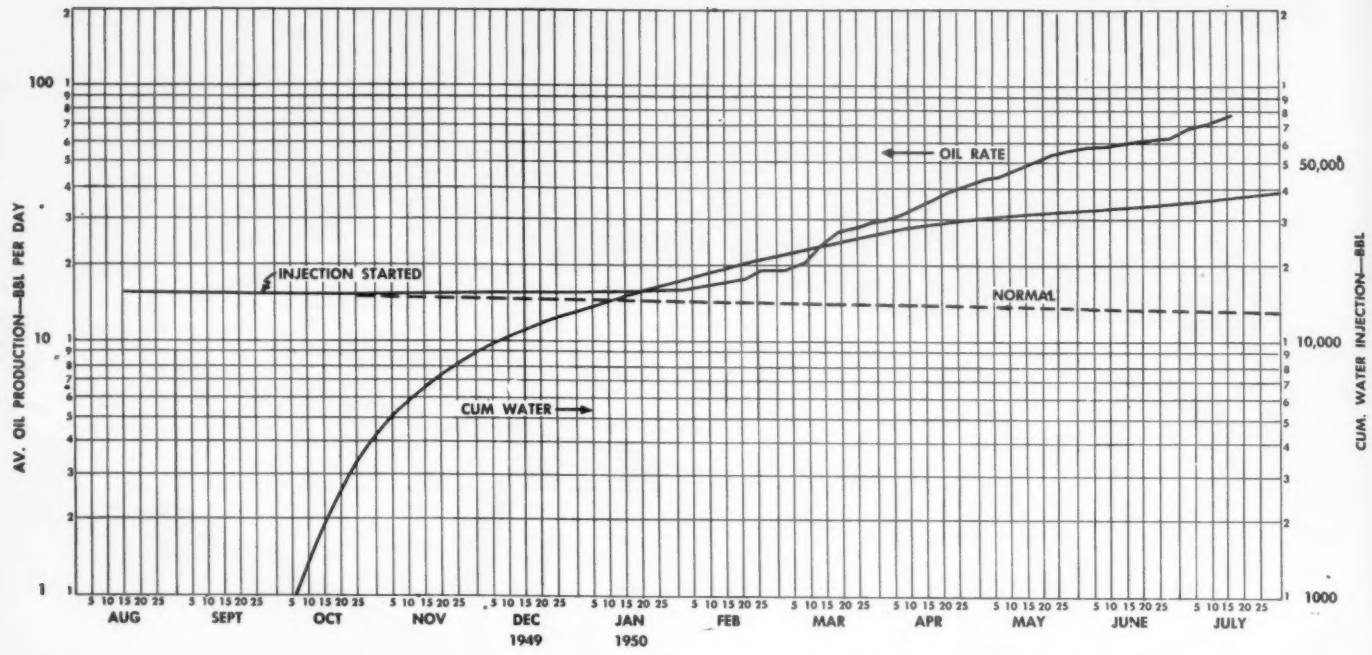

FIG. 1. PILOT test performance normal decline and actual production — L. Whitchurch lease, wells 1 and 2.

Performance of a Cypress Sand Flood

Yield under peripheral injection pattern in the Odin field, Marion County, Illinois, more than doubles primary recovery

LEON KRAUSE

Primary Production History

Development. The discovery well in the Odin field near Salem, Marion County, Illinois, was drilled by Buell and Doran on the Martha Young Lease in May 1945. The well had 14 ft of "pay" section, an initial potential of 125 bbl per day, and a total depth of 1760 ft. The drilling program was relatively rapid and by the end of December 1945 there were 22 producing wells in the field. Three additional producers were drilled in the northwest corner of the field in June 1948, resulting in 25 wells producing from the Cypress formation. The development program was done on a normal 10-acre spacing pattern. See Tables 1 and 2.

Expulsive force that produced the crude was predominately expansion of dissolved natural gas. The decline curve for the Ashland-Whitchurch lease, however, showed evidence of a partially effective natural water encroachment, but was of such small magnitude that the over-all effect was negligible. Subsequent drilling confirmed the presence of edge water.

Rate of decline for primary production was relatively rapid because of the low efficiency of dissolved gas expansion.

TABLE 1. Tabulation of primary production — barrels.

Date	Producing wells	Gross production	Cumulative production
1945	22	84,442	84,442
1946	22	134,571	219,013
1947	22	73,103	292,116
1948	25	51,973	344,089
1949*	25	36,647	380,736

* To December 1, 1949.

TABLE 2. Tabulation of gross daily average production — barrels.

Date	Daily average
December 1945	545
December 1946	260
December 1947	165
December 1948	122
November 1949	92

Characteristics of the Reservoir

Producing horizon in the Odin field is the Cypress sand, which averages about 1750 ft depth, lying immediately below the Barlow lime. Locally the "pay" is often referred to as the Odin sand.

The reservoir is an elliptical stratigraphic trap with a permeability pinchout to shale on the west, north, and east. In the south direction there is a transition from the oil saturated zone to water. Oil-water contact was established at an approximate subsea depth of 1240 ft.

The productive area of the field, planimetered from the isopachous map, was determined at 365 acres with an average thickness of 11 ft of sand. The total reservoir volume is approximately 4000 acre-feet and original oil in place was calculated to be approximately 4,000,000 bbl.

Sand Characteristics

Physical properties of the Cypress sand are as follows:

Average permeability, md	80
Average porosity, per cent	19.75
Connate water saturation, per cent	33
Rel. perm. at resid. oil sat., per cent	13.5

Physical properties of the crude

Gravity, degrees API	38
Viscosity, cp. at res. temp.	8
Gas in solution, est cu ft/bbl	30
Original bhp est, psi	700

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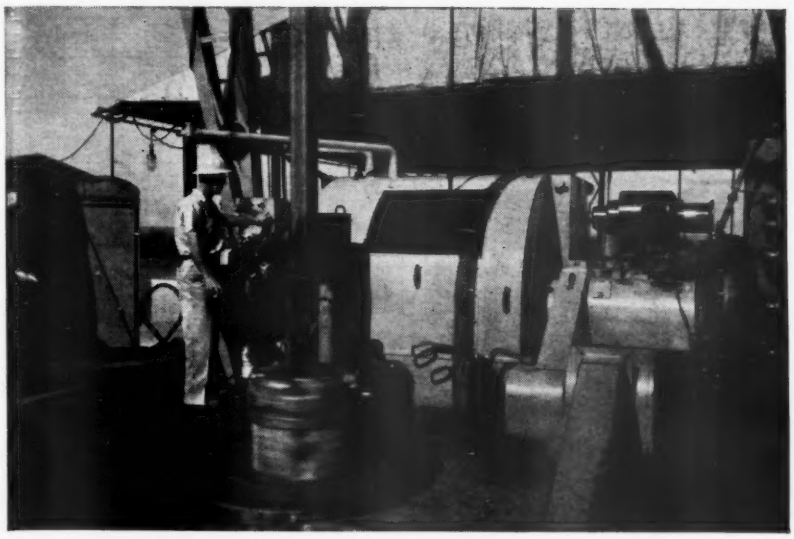

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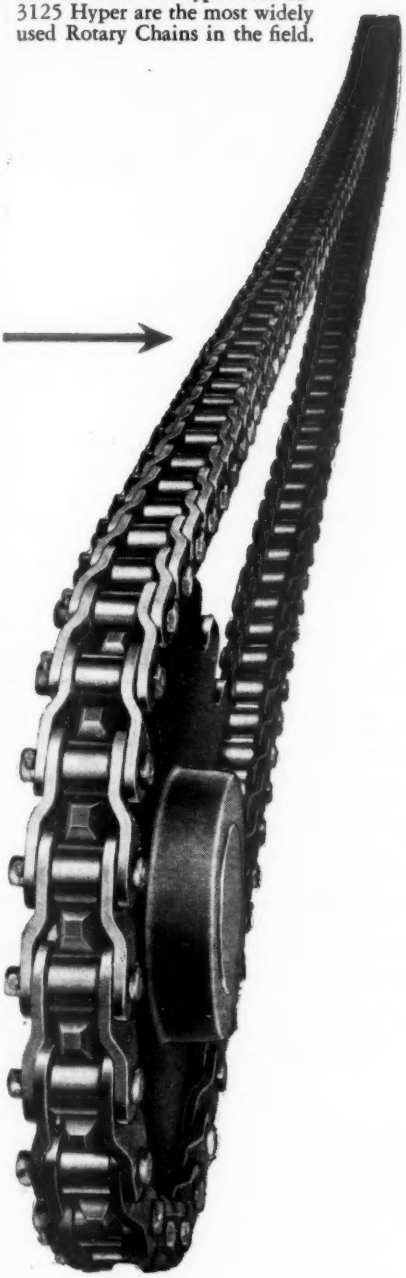

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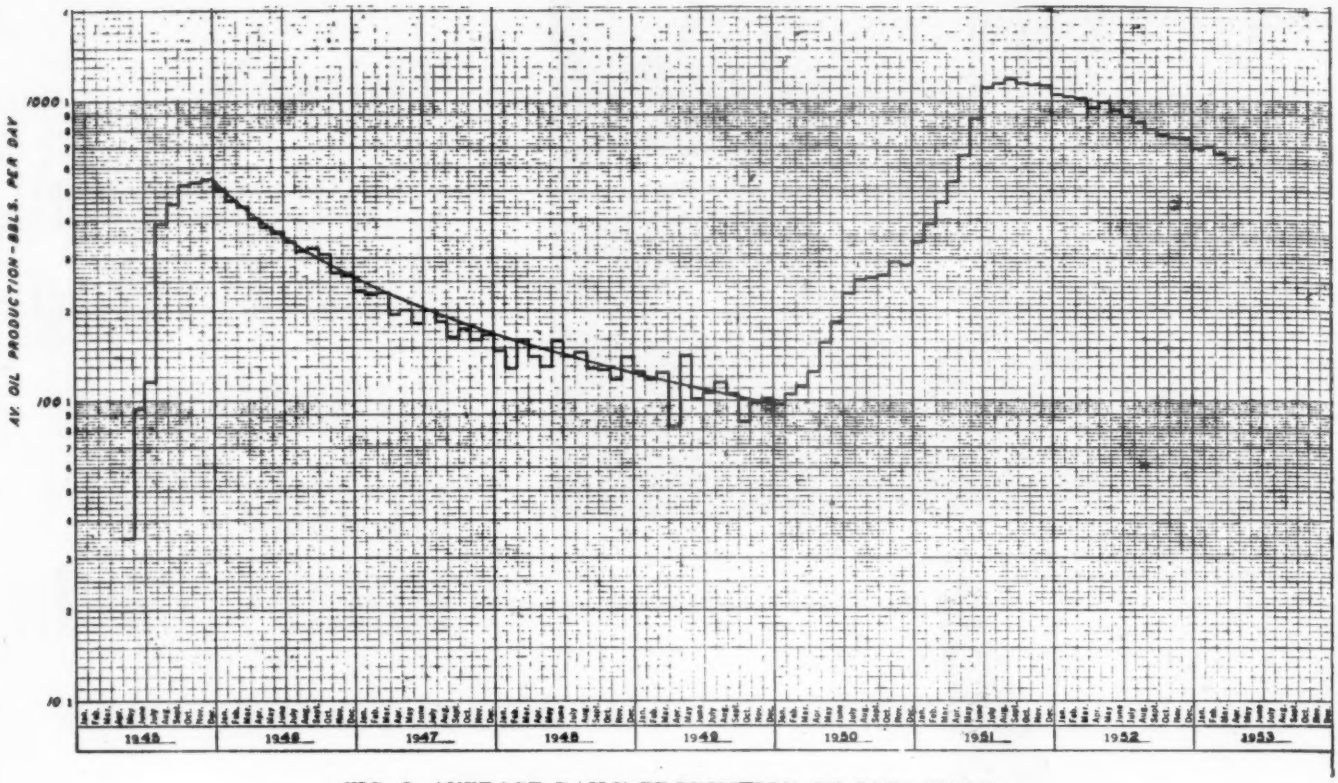

FIG. 2. AVERAGE DAILY PRODUCTION OF ODIN FIELD.

Secondary Recovery Program

The decline in primary production prompted an investigation of the waterflooding possibilities of the Odin field. Results of an engineering study revealed a large secondary reserve, and several different injection patterns were given consideration, but a decision was reached to adopt the external or peripheral type. Alternate wells were converted to inputs, and when necessary, new wells were drilled to inject water on the perimeter of the field. Plans included provisions to conduct an experimental or pilot flood.

The Author

Leon Krause, division waterflood engineer with Ashland Oil and Refining Company, has had 20 years of experience in secondary recovery of oil engineering problems principally in the oil fields of Pennsylvania, Oklahoma, Kansas, and the Illinois Basin since his graduation from Pennsylvania State College in 1933. He has been a pioneer in solving many problems related to waterflooding. He is now supervising the installation and operation of more than a dozen waterflood projects in Illinois and has at least a dozen more in the planning stage, many of which have the operational problems discussed in this article.

Pilot Flood

Prior to the commencement of the full-scale flooding program, a pilot test was conducted in order to determine the susceptibility of the Cypress sand to flooding. The Ashland-H. Elliott No. 1 well was chosen for conversions to an input and the results of injection were observed on offset producing wells. The Buell and Doran-R. Young No. 6 well was drilled to the Cypress, a temporary plug was set, the casing opposite the water bearing Tar Springs formation was perforated, and the well was completed as a temporary water supply. An analysis of the Tar Springs brine indicated that no chemical treatment was necessary, but facilities were installed to introduce a sequestering agent in the form of complex metaphosphates to hold the mineral matter in solution. A temporary aloxite tube filter was placed on the line in front of the meter for the removal of impurities, with the in-well pump on the water supply well serving a dual purpose of lifting and injecting.

Pumping equipment was removed from the Ashland-H. Elliott No. 1 well, the well was cleaned out, and readied for injection. Water injection begun September 29, 1949. See Table 3.

Injection was continued in the pilot flood to March 31, 1950, at which time the daily oil rate was 29 bbl. (Fig. 1).

Unitization

The peripheral-type injection pattern necessitated unitization of the field. Participation factors in the unit were based on daily production and reservoir volume.

The injection pattern for the full-scale flood required the drilling of two inputs, five producers, and two water-source wells, and the conversion of eight producers to inputs. (Fig. 3).

Water System

The water bearing Tar Springs formation, at a depth ranging from 1500-1600 ft, and with a thickness from 50-75 ft, blankets the field. Water supply wells were drilled through the formation with rotary tools and 5½-in. casing set and cemented below the water sand. Casing opposite the Tar Springs was gun perforated with four shots per foot. Static fluid level was 250 ft from the surface.

The pressure plant is operated on a closed system. The two water supply wells pump the brine into a 1000-bbl wooden raw water tank in which an oil

TABLE 3. Pilot flood input well data.

Date	Daily average (bbl)	Cumulative (bbl)	Surface pressure psi
October 15, 1949	133	2,126	0
October 31, 1949	163	4,742	10
November 15, 1949	139	6,820	10
November 30, 1949	150	9,071	10
December 15, 1949	145	11,250	15
December 31, 1949	164	13,877	20
January 31, 1950	141	17,823	70
February 28, 1950	177	22,776	70
March 31, 1950	115	26,338	70
April 30, 1950	138	30,488	70
May 31, 1950	49	31,998	35
June 30, 1950	126	35,789	100
July 31, 1950	104	38,997	100

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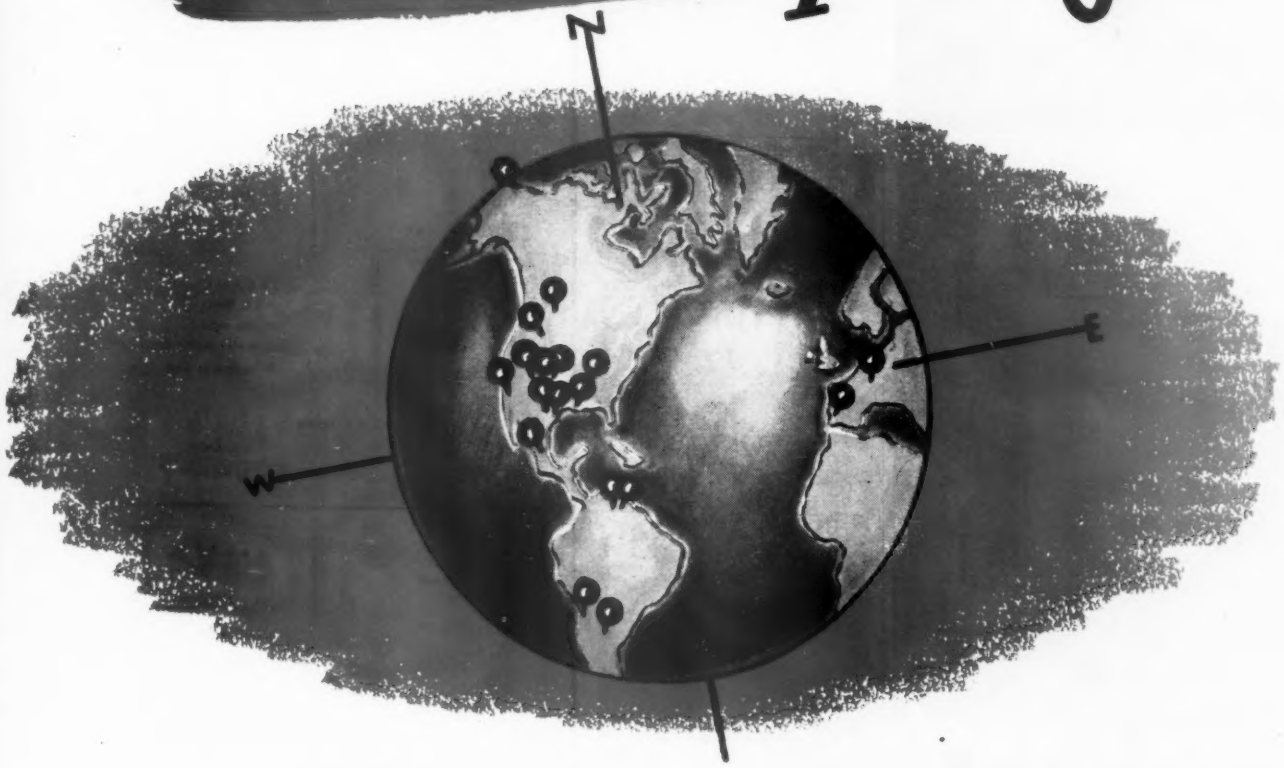

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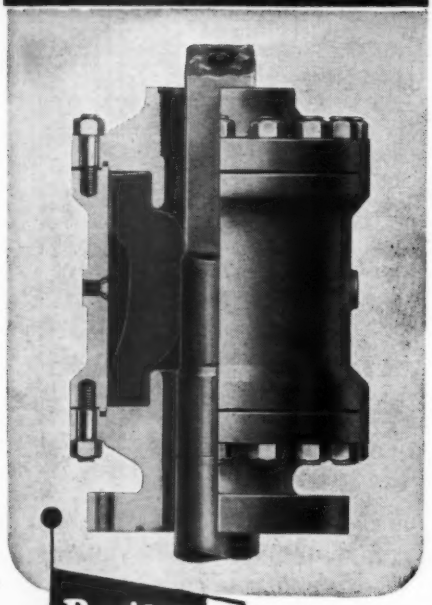

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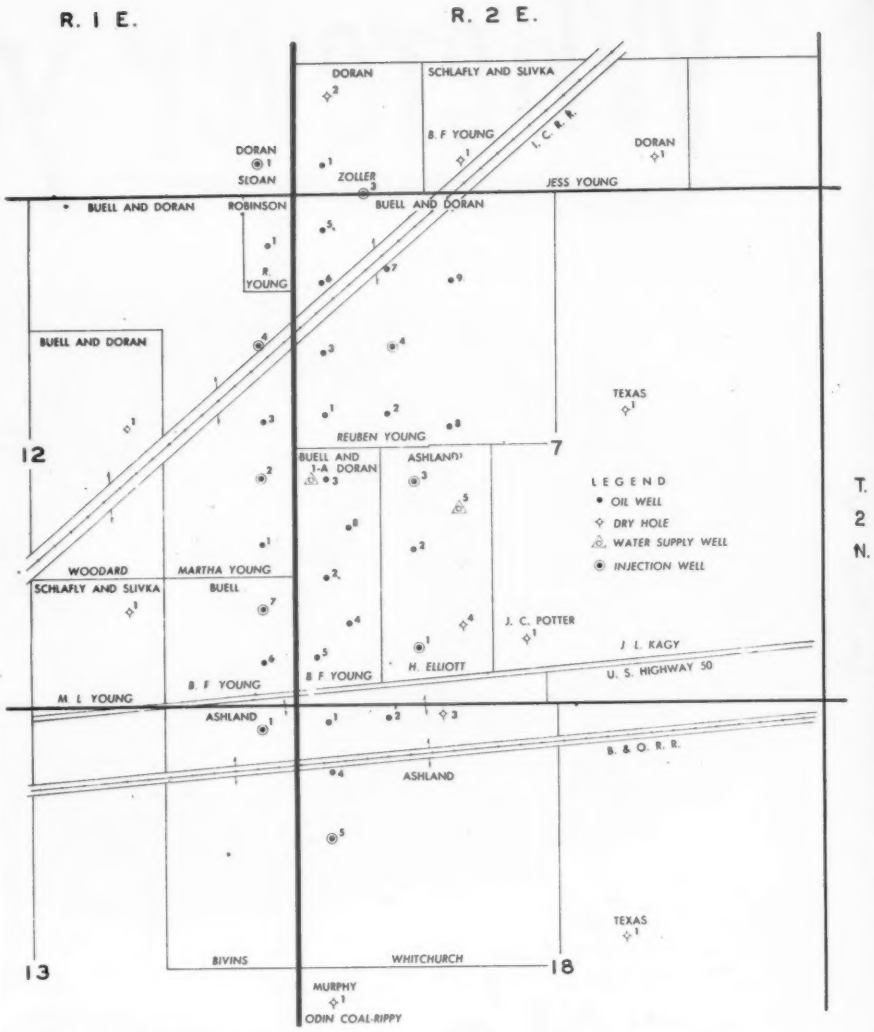

FIG. 3. WATERFLOOD project of Odin field at Marion County, Illinois.

seal is maintained to prevent exposure of the water to the atmosphere. A centrifugal circulating pump is connected to the raw water tank and moves the brine from the supply tank through a rapid sand filter into two 1000-bbl wooden clear water tanks. A sequestering agent is added on the discharge side of the filter. Oil seals are also maintained in the clear water tanks, with predetermined water levels maintained in all tanks by liquid-level controls which activate the pumping units on the water supply wells and the motor on the circulating pump.

Water is drawn from the clean water tanks by an electrically driven 1¾-in. by 4-in. vertical triplex pump, discharged into the trunk line, and thence distributed by laterals.

TABLE 4. Consolidated data.

Sand	Cypress
Depth	1750 ft
Producers	22 wells
Original spacing	10 acres
Water inputs	10 wells
Flood pattern	Peripheral
Water source	Tar springs
Water supply	2 wells
Production before flood	92 bbl
Peak production	1192 bbl
Cum. injection	1,324,600 bbl
Primary recovery prior to flood	380,736 bbl
Recovery in flooding operations	794,308 bbl
Cum. recovery to June 1, 1953	1,175,044 bbl

Produced water is collected in the pit, adjacent to the consolidated tank battery, and recycled.

Water Flood Performance

The pilot flood was begun on September 29, 1949, and when results of the experiment were considered successful, plans were made for the full scale installation. Peak production was reached in September 1951 when the daily average oil production for the month was 1192 bbl. Daily average water injection was 1200 bbl. Daily average oil production for November 1949 was 92 bbl.

The field had produced 384,253 bbl from December 1, 1949, to January 1, 1952. Oil produced in that period was 3500 bbl in excess of the primary recovery from May 1945 to December 1, 1949. Cumulative recovery from the field as of June 1, 1953, is 1,175,044 bbl. The primary oil produced prior to December 1, 1949 is 380,736 bbl and recovery by waterflooding operations from December 1, 1949 to June 1, 1953 is 794,308 bbl. See Table 4. Ratio to date is in excess of 2 to 1.

The pressure plant is operating with a daily average capacity of 1200 bbl at a pressure of 900 psi. Cumulative water injected to June 1, 1953 is 1,324,600 bbl.

* * *

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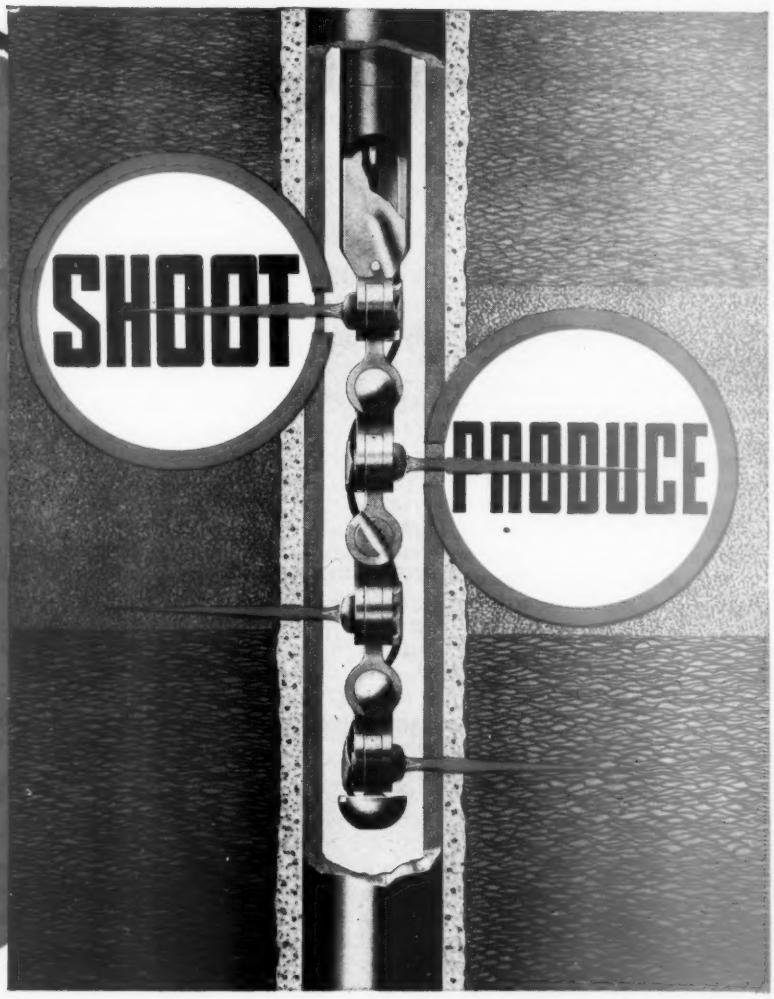

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A Practical

Application of Fluid Hydraulics to Drilling

in California

GENE D. THOMPSON*

A series of papers has been presented in the Southwest area concerning each phase of the research, development and optimum application of fluid hydraulics to drilling. This drilling technique better utilizes the available hydraulic horsepower of a rotary rig to efficiently effect a substantial improvement in bit performance, and consequently, a reduction in the overall drilling time. A trend toward deeper drilling with higher operational cost emphasizes the necessity for a well-balanced rig, designed with the hydraulic equipment commensurate with the hoisting capacity. From a practical standpoint, the degree of approach to optimum hydraulic horsepower must be based on an economic evaluation of the resultant savings and a possible increase in the cost of operations.

During the past several years an extensive research program has been conducted by Humble Oil and Refining Company to determine how the various hydraulic and mechanical factors affect the performance of drag-type and rock bits. Results of this study have been the basis for the design of jet-type drag bits and integral jet-type rock bits which are currently available to the drilling industry, as well as the engineering information to assist in their economical application.

This paper presents a chronological history of extensive laboratory and field tests which have been conducted with particular emphasis placed on such data as pertain to power rigs. In order to assist in outlining a practical program for California operations, representative curves and nomographs have been included for clarity and more rapid calculations. These data are sufficiently detailed to assist as a guide in outlining and designing more efficient hydraulic systems.

The summary presented on current jet-type rock bit operations in the Ventura, Los Angeles and San Joaquin Basins indicates a marked improvement of bit performance; however, these field data clearly illustrates the necessity for continued research and development in the field of hydraulics of rotary drilling in California.

†Presented at the spring meeting of the Pacific Coast district, Division of Production, American Petroleum Institute, Statler Hotel, Los Angeles, California.

*Petroleum Engineering Section, California area, Humble Oil and Refining Company.

A RECENT survey of drilling activities on the West Coast indicates that approximately 90 per cent of the 195 to 200 drilling rigs in California are power rigs. More than 85 per cent of these power rigs are equipped with 4½-in. OD drill pipe and drill 9⅞-in. or 10⅝-in. diameter hole with a single slush pump rated at less than 400 hydraulic horsepower, based on 85 per cent mechanical and 90 per cent hydraulic efficiency. A second slush pump of equivalent capacity is normally maintained for standby purposes and mixing mud; only about 10 per cent of these rigs are equipped with a third pump or mud agitator to effectively permit parallel pump operations.

With the exception of a few of the smallest rigs, the majority of those operating in California have sufficient pump capacity and prime movers to effect a noticeable improvement in bit performance by adjusting the volume of mud circulated in relation to the nozzle velocity to obtain the maximum product. In most cases, minor changes in the equipment will be necessary to utilize the available hydraulic horsepower to maximum advantage. The basic difference is the requirement for a high-pressure, medium-volume circulating system rather than the conventional medium-pressure, high-volume system.

It should be emphasized that running a jet-type bit in the hole without proper consideration of the horsepower available and circulating system will not result in improved bit performance. As the prime movers on a power rig lack the versatility normally associated with a steam rig, a practical knowledge of hydraulic equipment is required to prevent the circulating pressure from exceeding the capacity of the power pump.

In Humble's operations, better utilization of the available hydraulic horsepower, improved mud programs, properly designed bit programs, use of larger drill collars and higher bit weights and foresight in purchasing new rig equipment have all contributed to a reduction in drilling cost.

Hydraulic Principles of Drag Bit Drilling

Humble first recognized the advantage of increased nozzle velocity and its effect on drilling rates of drag bits during a series of field experiments several years ago. These early tests led to the establishment of a research project to conduct an intensive study of all hydraulic and mechanical factors which affected the rate of penetration of drag bits. The resulting study,[1] based on drilling over 100,000 ft of hole in 26 wells, developed two important fundamental relationships—at the maximum effective bit weight which may be carried on a drag bit (1) the drilling rate is directly proportional to the nozzle fluid velocity and (2) the drilling rate is directly proportional to the fluid circulating rate. It follows that the drilling rate is proportional to the product of the two. A mathematical analysis[2] reduced these known relationships to generalized equations for determination of the optimum hydraulic conditions necessary for the maximum penetration rate. If the depth and available hydraulic horsepower for a circulatory system are known, the optimum nozzle size and circulating rate can be determined by calculating which program will give the maximum product of the nozzle velocity and circulating rate. A graphical solution for both 4½-in. and 5-in. OD drill pipe at each 1000-ft interval, similar to that illustrated in Fig. 1, simplifies these calculations.

Arrangement of the jet stream, shown in Fig. 2 fully utilizes the 200 to 400-ft-per-second nozzle fluid velocities to disintegrate and remove all cuttings rapidly from bottom. The turbulence created by the impact of the two jets keeps the cutter blades and the newly exposed formation free of all adhering materials. The selection of optimum size nozzles to provide this required energy resulted in an initial average decrease of 48 per cent in rotating time accompanied by a 45-per cent increase in footage per bit. Based on field tests, the drilling industry quickly adopted this new technique; current sales indicate that over 50 per cent of the drag bits are equipped with properly sized nozzles.[1,2]

Hydraulic Principles of Rock Bit Drilling

Some time ago Humble initiated tests to determine how these various hydraulic and mechanical factors affected the penetration rate of rock bits. Modifying the conventional rock bits and equipping them with high velocity jets di-

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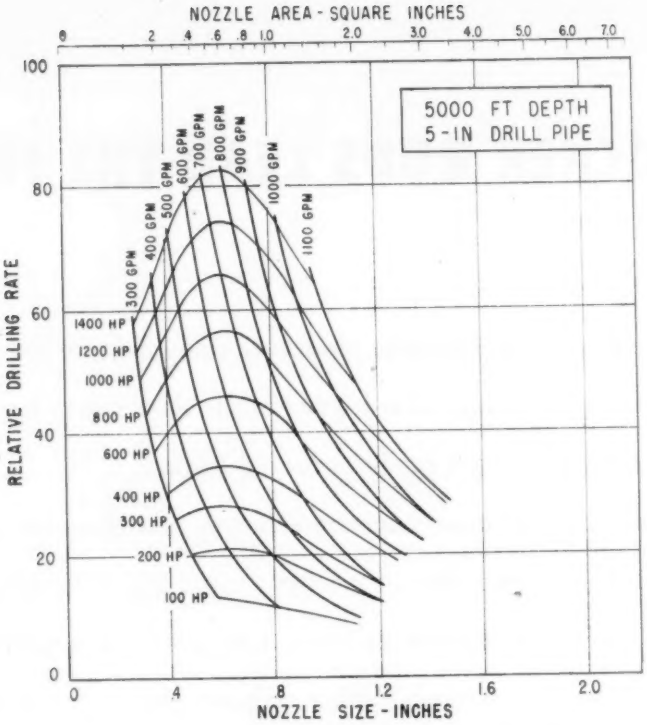


FIG. 1. Relation of drilling rate, nozzle diameter, circulating rate, and hydraulic horsepower at 5000 ft depth for jet drag bits. (10.3 lb/gal or 77 lb/cu ft mud and 0.8 nozzle coefficient.)

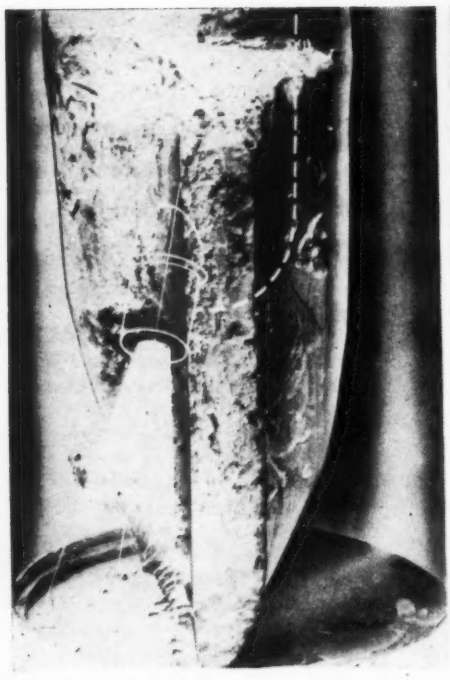


FIG. 2. Jet Drag Bit.

FIG. 3. Jet Rock Bit.

rected at the bottom of the hole presented a more complex design problem than that encountered with drag bits. Once again this work was coordinated with the research departments of bit manufacturers. The outcome of these early developments are the present integral jet rock bits which are commercially available from all major rock bit manufacturers for the current premium price of $30 per bit. The two-cutter and cross sectional bits are each equipped with two jet nozzles, whereas the three-cutter design incorporates three nozzles. Fig. 3 illustrates that the only radical departure from the conventional bit consisted of modifying the direction of the fluid stream to establish the necessary jet action.

Conventional rock bits rely on relatively low fluid velocities through large watercourses directly above the cutters to clean the bit and hole. Although an appreciable increase in circulating rate will improve this cleaning action and, in most cases, the drilling rate, the bit footage life is substantially decreased by excessive erosion of the cutters. This disadvantage has been eliminated by the jet-type rock bit; however, it must be recognized that exceptionally low nozzle velocities could increase balling-up tendencies due to insufficient turbulence and, consequently, decrease the drilling rate. A jet-type rock bit must rely on high fluid velocities to disintegrate and remove the cuttings rapidly from bottom to eliminate the lost energy of re-grinding the cuttings. Tests to determine the exact relationship of hydraulic and mechanical factors to bit performance are now in progress.

Results of using a special duplex sub, which permits conversion from conventional to jet watercourses without round-tripping the drill pipe, have indicated increases in drilling rate of 50 per cent or more at constant bit weight and rotary speed. This sub contains a spring-loaded valve plate which is rotated by a cam each time the pump is started, thereby alternating the type of watercourses in the bit. One of the typical tests which illustrates the advantages of jet over conventional type watercourses is shown in Fig. 4.

Jet-Type Rock Bit Performance

The drilling rate curves in Fig. 5 graphically illustrate the effect of nozzle velocity on the rate of penetration for jet-type rock bits at varying bit weights. These results indicate that when drilling at constant circulating rates and rotary speeds, the maximum weight that may be applied without balling up the bit increases as the nozzle velocity is increased. Under these conditions the drilling rate is essentially a linear function of the bit weight up to that point at which the bit begins to ball-up. Although these balling-up points will differ for the many types of bits and formations, these data emphasize an important fact—little can be expected from increased nozzle velocities unless it is accompanied by a proportional increase in bit weight or unless the bit is balled-up prior to increasing the nozzle velocity. The rate of increase in penetration rate with bit weight will depend largely on the hardness of the formation and will vary from 1:1 to as low as 1:10 for extremely hard formations. This is principally due to the necessity of exceeding the compressive strength of the formation in order to pass from the stage of wearing out to that of chipping and fracturing the formation.

Controlled field tests have also established that in most formations the penetration rate of jet-type rock bits is a linear function of the rotary speed and that the rate of increase is dependent on the formation hardness. A rotary speed must be selected in conjunction with the bit weight for each depth and type formation to provide the maximum penetration rate at the most economical drill pipe service. As a practical application of jet-type bits does not permit both

FIG. 5. Effect of nozzle velocity and bit weight on rate of penetration of jet rock bits.

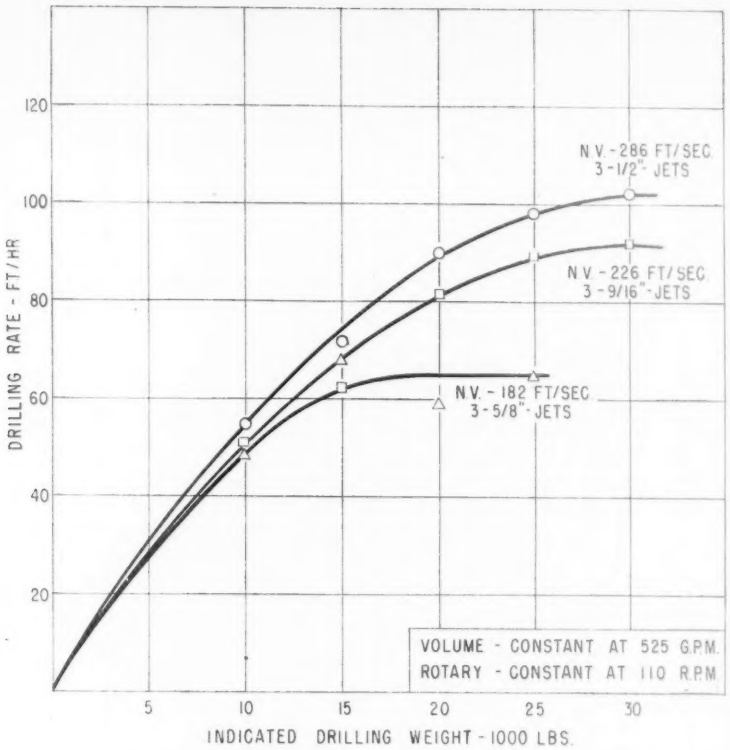
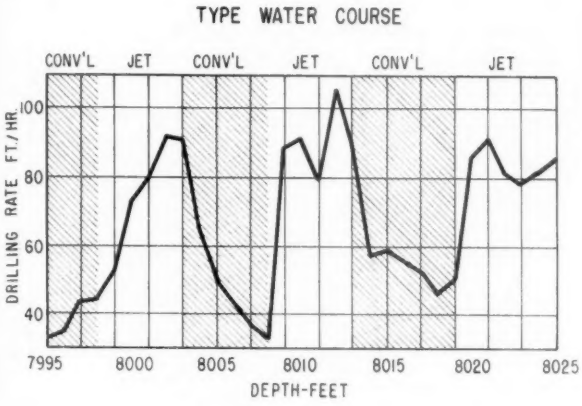


FIG. 4. Typical test results using duplex sub in soft formation.



maximum attainable bit weight and rotary speed, it has been developed that it is usually more beneficial to reduce rotary speed and maintain the higher weight. These variables must be continuously evaluated for both routine and problem wells since the large number of formations with steep dips in California make it necessary to constantly control the tendency of the hole to deviate from vertical. This limitation emphasizes that the successful use of jet-type rock bits, in a large respect, depends upon the ingenuity of each driller to select the proper combination of nozzle size, bit weight, rotary speed, and circulating volume; factors over which he has direct control.

In addition to the effect of these factors, the penetration rate of rock bits is also influenced by the physical properties of the drilling fluid. With all other conditions constant, the use of a mud may reduce the drilling rate obtainable with water by as much as 50 per cent. The magnitude of this reduction is dependent upon the quantity and type of suspended solids in the mud. It is possible to retard this tendency of the bit to ball-up in most cases by higher circulating rates or by an alternation of mud properties. If moderately heavy muds are desired, it has been found advantageous, so far as the drilling rate is concerned, to obtain the increased density by means of a high quality weighting material, with small additions of bentonite if necessary, rather than by use of clay alone. Excessive mud weights will load the pump capacity prematurely since the pressure losses in a circulating system are directly proportional to the mud density. Consideration should also be given to modifying such restrictions as small ID surface piping, drill pipe, and drill collars to extend the economical depth of improved bit performance.

Laboratory and field tests have determined that the drilling rate is directly proportional to the filtration loss and inversely proportional to the solid content. It was also indicated that the increase in drilling rate normally obtained with oil-emulsion muds is due to lubrication effects, which results in a high percentage of the surface-indicated bit weight being effective on bottom.

Outlining a Jet-Type Rock Bit Program

Although the several years of continuous research in hydraulics of rotary drilling have made a significant contribution to the drilling industry, there still remains no simple "cut-and-dried" jet-type rock bit program that is adaptable to every condition. Knowledge of operational characteristics of each rig is required to effectively outline and initiate a workable program; i.e., maximum hydraulic horse power that can be maintained continuously, maximum advisable pump pressure, feasibility of parallel pump operations, and selection of drill pipe and hole size. Basically, a practical jet-type rock bit program may be determined in the same manner as the jet-type drag bit program previously mentioned.[2] Where three nozzle bits are utilized, the nozzle diameters should be adjusted to give the same total nozzle area as if two were used. As a limiting condition, the horsepower required to give the minimum allowable annular velocity should be calculated and the circulating rate used should not be allowed to fall below this figure. This condition will normally govern the program only at great depths or in very large holes being drilled with small drill pipe. After determining the horsepower required for the minimum return velocity and that required to circulate the required amount of mud through the drill pipe and surface connections, the remaining horsepower should be utilized in the bit nozzles. Since improved mud properties and decreased drilling rates at greater depths usually require less annular velocity, it is important to determine the best depth for liner changes, if necessary, to avoid overloading pumps and prime movers.

The minimum mud return velocity is a factor that should be determined in each field for the different type muds and hole sizes. Annular velocities of 150 to 160 ft per minute have proved adequate for most operations on the West Coast; velocities as low as 100 ft per minute have been used successfully in some instances for drilling rates of 10 to 15 ft per hour at depths below 10,000 ft. Reduced hole sizes or large drill pipe will assist in attaining a safe mud return velocity with a lower rate of circulation.

Current field data indicate that a nozzle fluid velocity greater than 225 ft per second is necessary with 9⅞-in. or 10⅝-in. bits to effect consistently a significant increase in both penetration rate and footage per bit. A minimum nozzle velocity which will improve the bit performance in every circumstance cannot be defined because of the many controlling variables. It is possible that nozzle velocities below 225 ft per second may prove beneficial in certain formations; however, in many instances, this indicated improvement has resulted from comparison of erroneous data obtained while drilling with balled-up bits. Although the basic objective of using jet-type bits is to improve bit performance and lower cost, it is imperative that full recognition be given to all changes in the operating conditions. On many occasions reduction in hole sizes, changing type of bit, increasing rate of cir-

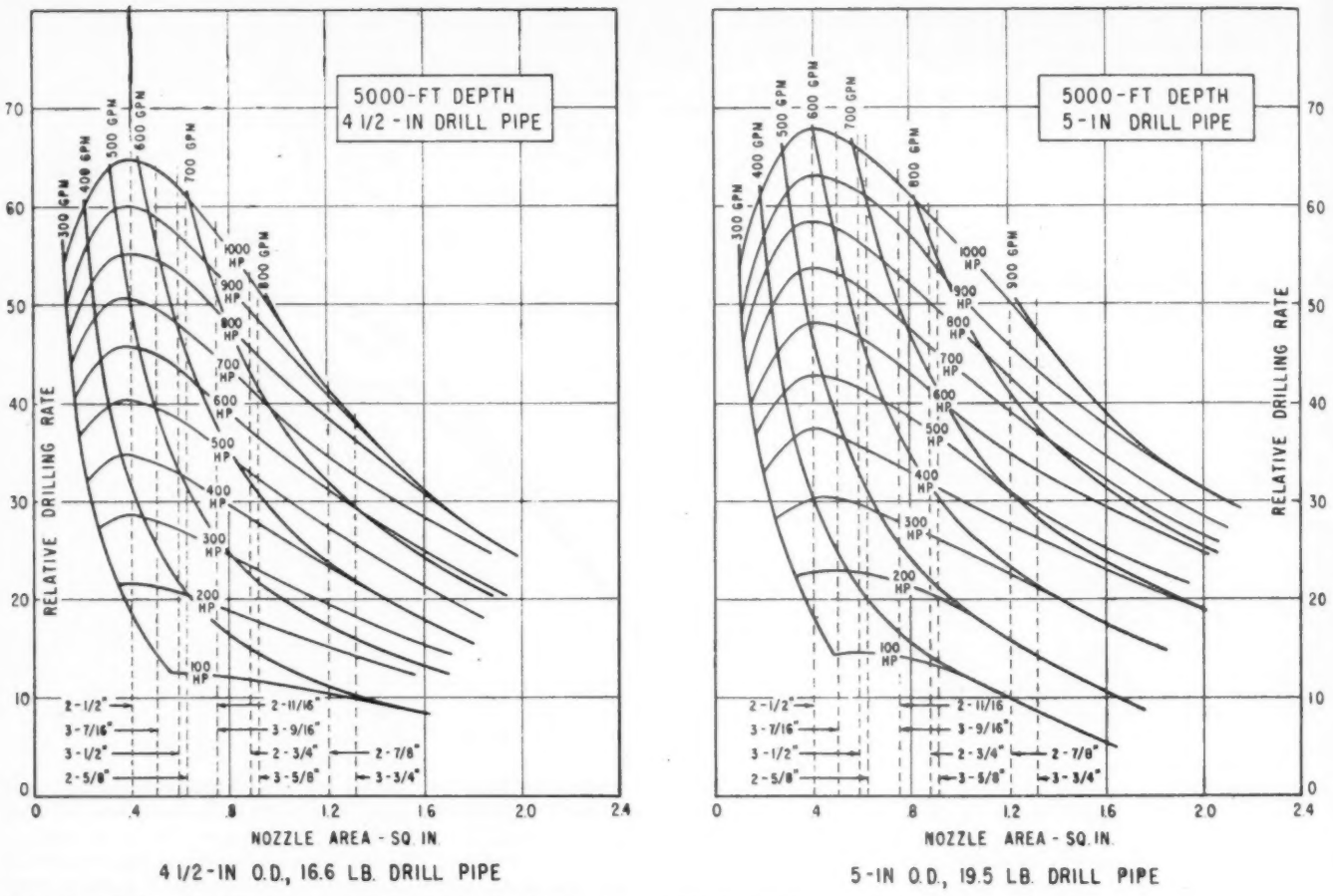

5000-FT DEPTH
4 1/2 - IN DRILL PIPE
RELATIVE DRILLING RATE
NOZZLE AREA - SQ IN
4 1/2-IN O.D., 16.6 LB. DRILL PIPE
5000-FT DEPTH
5-IN DRILL PIPE
RELATIVE DRILLING RATE
NOZZLE AREA - SQ.IN.
5-IN O.D., 19.5 LB. DRILL PIPE

FIG. 6. Relation of drilling rate, nozzle area, circulating rate and hydraulic horsepower at 5000 ft depth. (10.3 lb/gal or 77 lb/cu ft mud and 0.9 nozzle coefficient.)

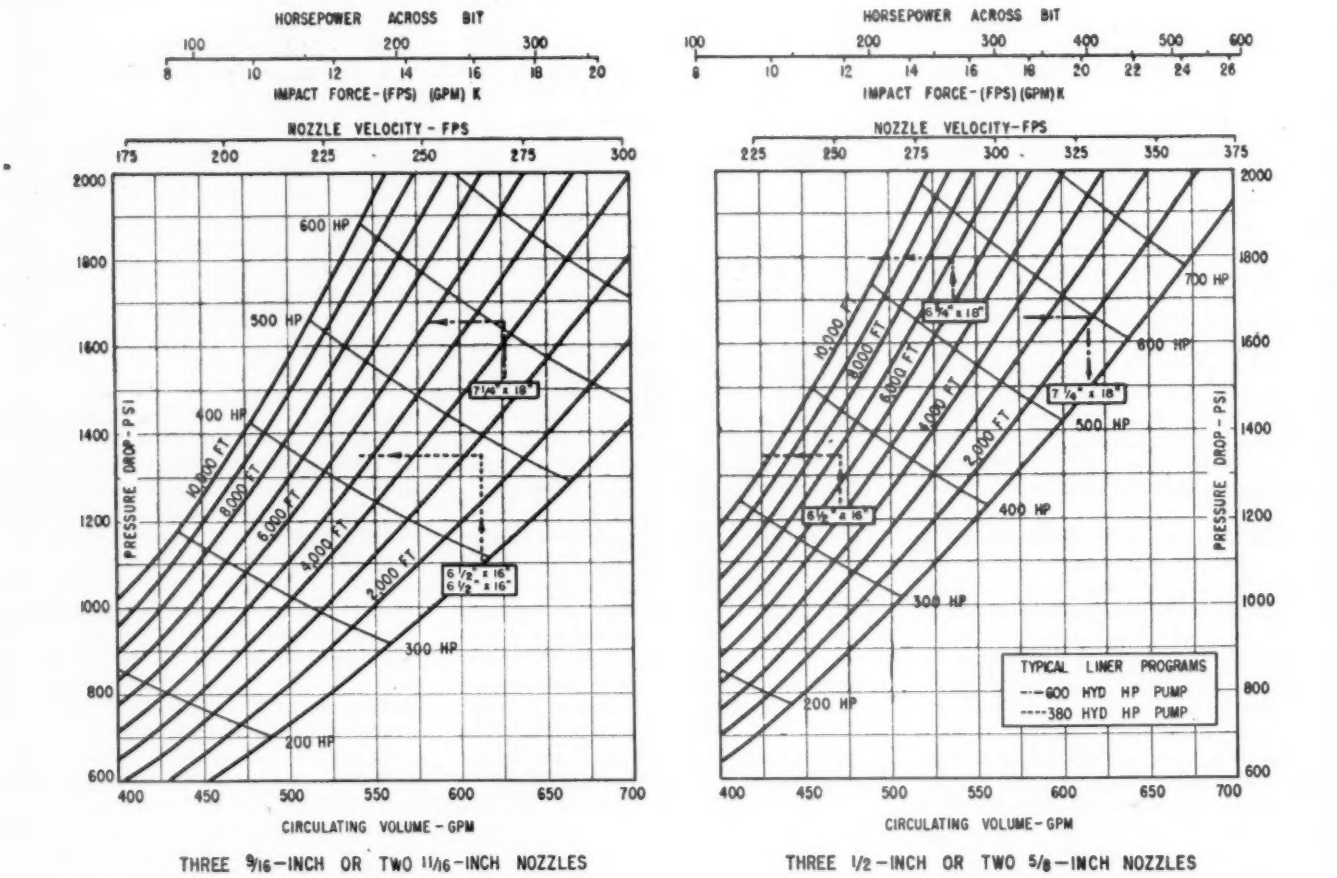

HORSEPOWER ACROSS BIT
IMPACT FORCE - (FPS) (GPM) K
NOZZLE VELOCITY - FPS
PRESSURE DROP - PSI
CIRCULATING VOLUME - GPM
THREE 9/16-INCH OR TWO 11/16-INCH NOZZLES
TYPICAL LINER PROGRAMS
---600 HYD HP PUMP
----380 HYD HP PUMP
THREE 1/2-INCH OR TWO 5/8-INCH NOZZLES

FIG. 7. Pressure drop curves for rig using 4½ in. OD, 16.6 lb drill pipe. (10.3 lb/gal or 77 lb/cu ft mud and 0.9 nozzle coefficient.)

XUM

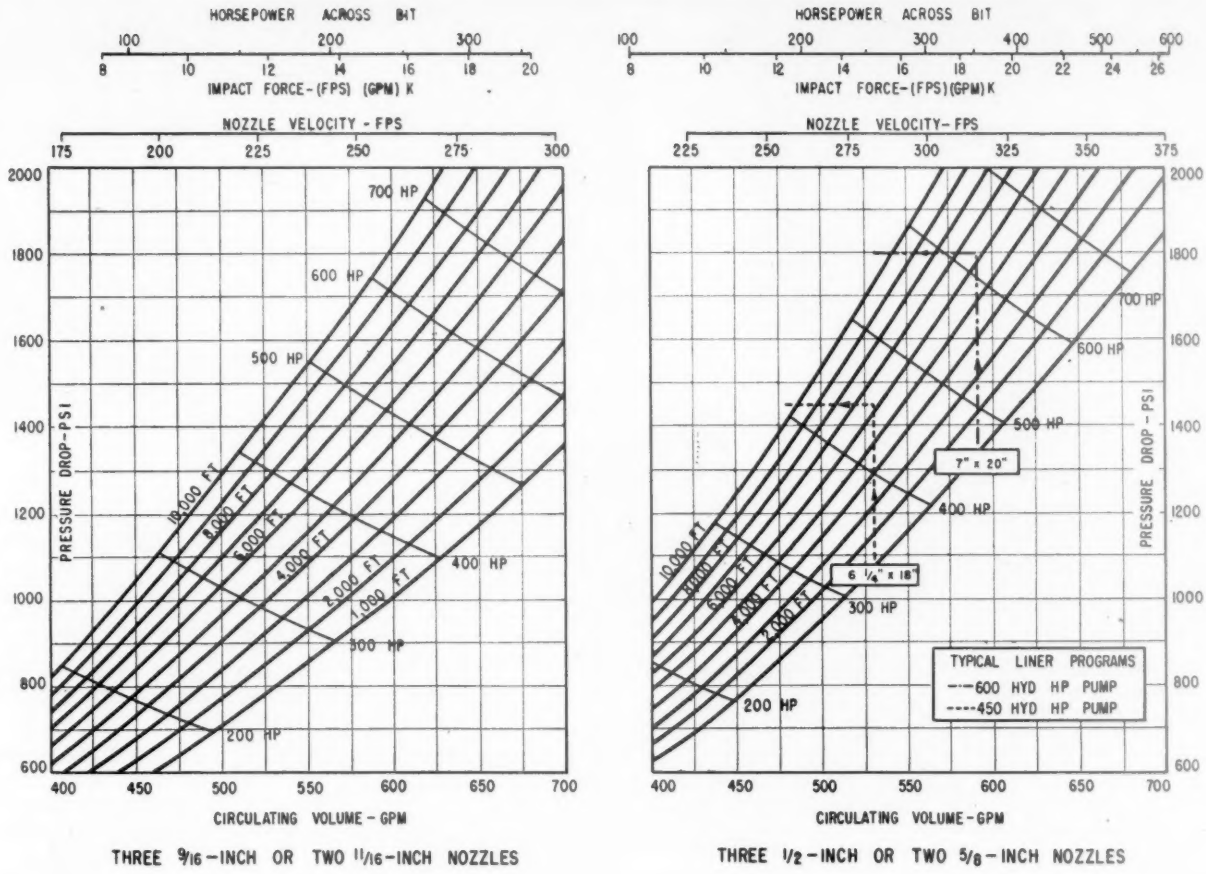


FIG. 8. Pressure drop curves for rig using 5 in. OD, 19.5 lb drill pipe. (10.3 lb/gal or 77 lb/cu ft mud and 0.9 nozzle coefficient.)

culation, etc., will have great effect on improved performance and make the value of the change in hydraulics difficult to evaluate. In any drilling study only one variable at a time should be investigated.

Controlled field tests are now in progress to further evaluate the hydraulic factor and penetration rate of jet-type rock bits in all types of formations. This research by Humble has shown that at the maximum effective bit weight just short of the balling-up point, the penetration rate is directly proportional to either the horsepower losses or impact forces at the bit. By mathematical substitution in available hydraulic formulas[3] for pressure in a mud system it is possible to show that these horsepower losses are directly proportional to the product of the circulating rate and square of the nozzle velocity; whereas, the product of the circulating rate and nozzle velocity is directly proportional to the fluid impact. One major operator, conducting similar experiments in Louisiana, has recently concluded that the latter relationship, impact force, is the controlling factor in their tests.

Referring to Fig. 1, which is based on impact force relationship, it is evident that a maximum drilling rate exists at a fixed hydraulic horsepower and depth for a two-way drag bit with 0.80 nozzle coefficient; the rate of fluid circulation, nozzle diameter and relative drilling rate for this maximum may be predetermined. A simplified solution of this mathematical analysis[2] for relative drilling rate disclosed that at constant hydraulic horsepower, a condition with approximately 75-per cent pressure drop across the nozzles produces the maximum drilling rate at the optimum operating conditions.

An investigation[4] of the design factors affecting the coefficient and flow characteristics of bit nozzles resulted in more efficient designs which materially reduce the pressure losses within the bit. Recent field tests in California indicated that the average nozzle coefficient is about 0.90 for four of the five major makes of jet-type rock bits; the fifth manufacturer is currently improving its nozzle efficiency. Using this new coefficient and resolving the generalized hydraulic equations[2] for total pressure drop and horsepower losses more characteristic of California operations, the relation of drilling rate, nozzle area, circulating rate and hydraulic horsepower for drilling at 5000 ft with 4½-in. or 5-in. drill pipe has been revised for rock bit application and plotted in Fig. 6. These optimum conditions have not included the minimum rate of circulation necessary for safe annular velocity; nevertheless, this circulating rate will be a controlling factor for some medium rigs drilling 9⅞-in. or 10⅝-in. hole.

Inasmuch as the optimum operating conditions, determined by the maximum from the constant hydraulic horsepower curve, do not vary appreciably for the different depths normally drilled by jet bits, Fig. 6 can be used as a general guide in selecting most practical liner and nozzle sizes for most rigs in California. Because of the limitation on discharge pressure and the hazard of overloading power pumps, it is sometimes advisable to select a nozzle size which occurs slightly to the right of the optimum if it will not materially reduce the relative drilling rate. As the slight reduction in pressure is partially compensated by an increase in volume at constant horsepower, the actual decrease in drilling rate is usually insignificant, particularly if hole problems restrict maximum effective bit weight.

Pressure drop curves for an average rig, using nozzle sizes most adaptable to present California practices, are illustrated in Figs. 7 and 8 for 4½-in. and 5-in. drill pipe, respectively. These pressure-volume curves for the three 9/16 or two 11/16-in. and three ½ or two ⅝-in. nozzles, based on average cross-sectional areas and 90-per cent pump volumetric efficiency, check within 96 to 98 per cent of the field data using water base muds. Constant pump horsepower, nozzle velocity, impact force, and horsepower losses through the bit have been included to further assist in determining the practical nozzle and line program for a particular rig. For convenience, the impact force has been shown relative to circulating rate and nozzle velocity.

Assuming the drilling rate to be directly proportional to the total impact force of the jets, for example, typical

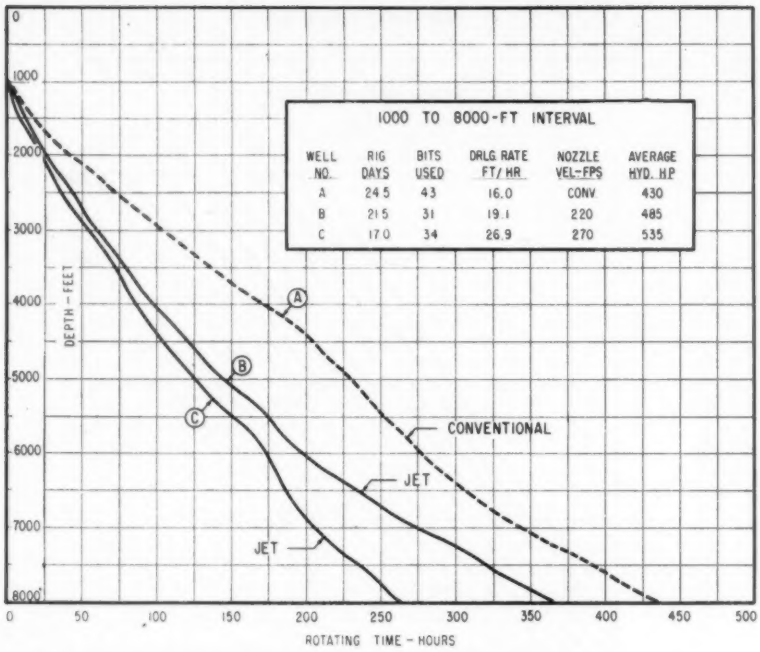

1000 TO 8000-FT INTERVAL
WELL NO. | RIG DAYS | BITS USED | DRLG RATE FT/HR | NOZZLE VEL-FPS | AVERAGE HYD. HP
A | 24.5 | 43 | 16.0 | CONV | 430
B | 21.5 | 31 | 19.1 | 220 | 485
C | 17.0 | 34 | 26.9 | 270 | 535
DEPTH - FEET
ROTATING TIME - HOURS
CONVENTIONAL
JET
JET

FIG. 9. Comparison of 9⅞-in. jet and conventional rock big drilling at Castaic Junction field.

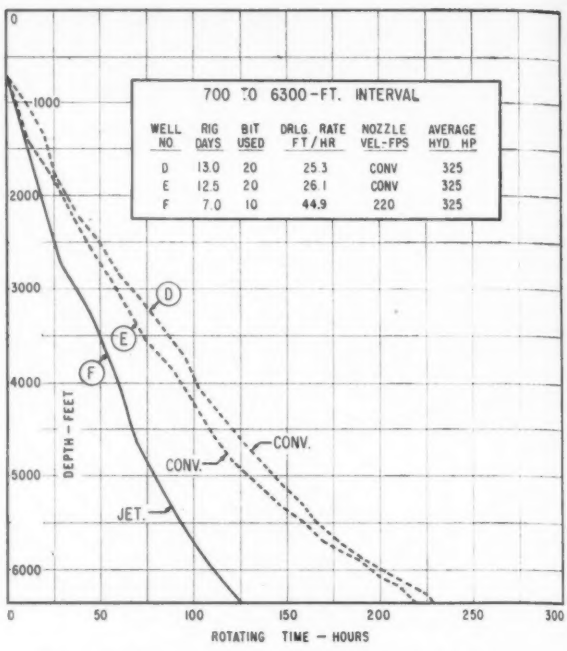

700 TO 6300-FT. INTERVAL
WELL NO. | RIG DAYS | BIT USED | DRLG RATE FT/HR | NOZZLE VEL-FPS | AVERAGE HYD. HP
D | 13.0 | 20 | 25.3 | CONV | 325
E | 12.5 | 20 | 26.1 | CONV | 325
F | 7.0 | 10 | 44.9 | 220 | 325
DEPTH - FEET
ROTATING TIME - HOURS
CONV.
CONV.
JET.

FIG. 10. Comparison of 9⅞ in. jet and 10⅝ conventional bit drilling and Ventura Avenue field.

programs for different pump capacities have been sketched in Figs. 7 and 8 to illustrate a method of effectively maintaining the maximum product of the circulating volumes and nozzle velocity. Should the drilling rate prove to be directly proportional to the horsepower loss through the bit, it can be mathematically shown that smaller nozzle sizes with still higher pump pressures would be required at optimum conditions. In either case, the pump pressure is a critical factor which becomes increasingly significant with depth. A closer approach to optimum conditions than generally outlined is not practical with current hydraulic equipment and large hole size.

As illustrated in Figs. 7 and 8, it is advisable to operate the pumps at less than maximum speed after obtaining the maximum recommended discharge pressure, in many cases, rather than change liner or nozzle size immediately. Most controls on power rigs are sufficiently versatile to permit a gradual reduction to 90 per cent of the rated speed, i.e., 60 to 54 strokes per minute, if the engines are near loaded capacity.

A majority of pump manufacturers rate a slush pump, more-or-less, on the life expectancy of the main bearings. Maximum recommended discharge pressure for each liner size is determined from a nominal input horsepower at maximum speed. Because of this pressure limitation, a reduction in pump speed necessitates a corresponding reduction in output horsepower. Although these specifications have been established to eliminate excessive load reversals in the power end, and, consequently, prevent a decrease in the life expectancy, some operators have economically justified a 10 to 25-per cent overload of pressure or horsepower for short periods of time in lieu of a major investment for larger pumps. In all cases, however, the pump manufacturers should be consulted to ascertain the feasibility of such practices.

A study of alternate hydraulic programs may determine a satisfactory revision of conditions without exceeding rated pump capacity and, at the same time, retain a comparable drilling rate. Two hydraulic programs listed in Table 1 for a medium-size rig with a single 500-nominal-input or 375-output-horsepower pump illustrate a method for avoiding overloaded power pumps. The reduction in liner and nozzle size, combined with a decrease in hole diameter, established a comparable drilling rate and annular mud return velocity without overloading the rated capacity of the pump by 28 per cent. It is interesting to note from Figs. 6 and 8 that, by substituting 5-in. drill pipe, the 1225 psi pressure limitation would permit a circulating rate of 505 gal per minute at 5000 ft and, consequently, a relative drilling rate of 34. This is a 17-per cent additional increase in penetrating rate provided the bit weight is increased accordingly. This hydraulic advantage of 5-in. drill pipe increases with depth and is a significant factor in jet-type drilling operations at this and greater depths.

TABLE 1. Comparative hydraulic programs at 5000 ft depth.

Hydraulic data	Actual conditions	Alternate conditions
Hole size	10⅝ in.	9⅞ in.
Drill pipe	4½ in. I.F.	4½ in. I.F.
Drill collars	7¾ in. x 250 ft	7¾ in. x 250 ft
Liner size	7½ in. x 16 in.	6¾ in. x 16 in.
Max. rated pressure	970 psi	1225 psi
Circulating rate	585 gpm (56 spm)	475 gpm (58 spm)
Annular velocity	160 fpm	150 fpm
Nozzle size	3⅝ in.	3½ in.
Nozzle velocity	204 fps	258 fps
Pressure losses		
Surface piping	70 psi	40 psi
Drill pipe	585	375
Drill collars	135	95
Bit nozzles	425	675
Annulus	30	45
Total	1245 psi	1230 psi
Hp at pump	425	340
Hp across bit	145	187
Impact-(fps)(gpm)K	11.9	12.3
Relative drilling rate	29	29

Performance of Jet-Type Rock Bits in California

Partially by a "trial-and-error" method, the operators and bit manufacturers combined their experience during 1951 and 1952 to solve most of the questions regarding the techniques of jet drilling. The frequent equipment failures initially associated with this new procedure emphasized the necessity for additional engineering "know-how" and job-planning. The greatest density of tests in California to determine the effect on the various factors affecting jet bit performance has been centered around Castaic Junction and Ventura operations. It has been obvious from these and other operations that, because of the different hydraulic equipment and drilling practices of each rig, it is virtually impossible to compare performances of one rig directly with another. With this fact in mind, routine applications of jet-type bits thus far indicate that medium, heavy, and extra-heavy power rigs are all capable of accomplishing a proportional improvement in bit performance according to the avaliable hydraulic capacity. The initial development was conducted on rigs equipped with the largest and most adaptable pumps without modifying the mud system; jet-type bits later proved to be successful on medium-size rigs after minor revisions. As always, new drilling techniques must be proven by each operator prior to justifying larger and more costly equipment if such is needed.

A comparison of 9⅞-in. jet and conventional bit data for an extra-heavy

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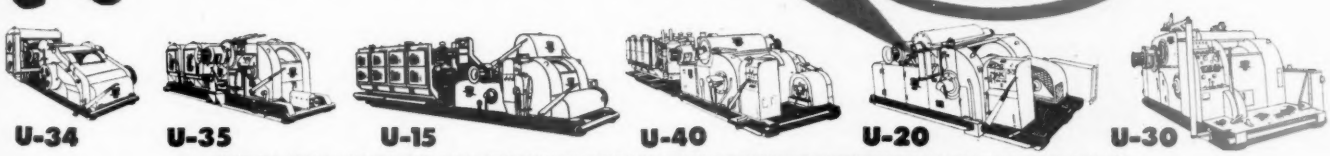

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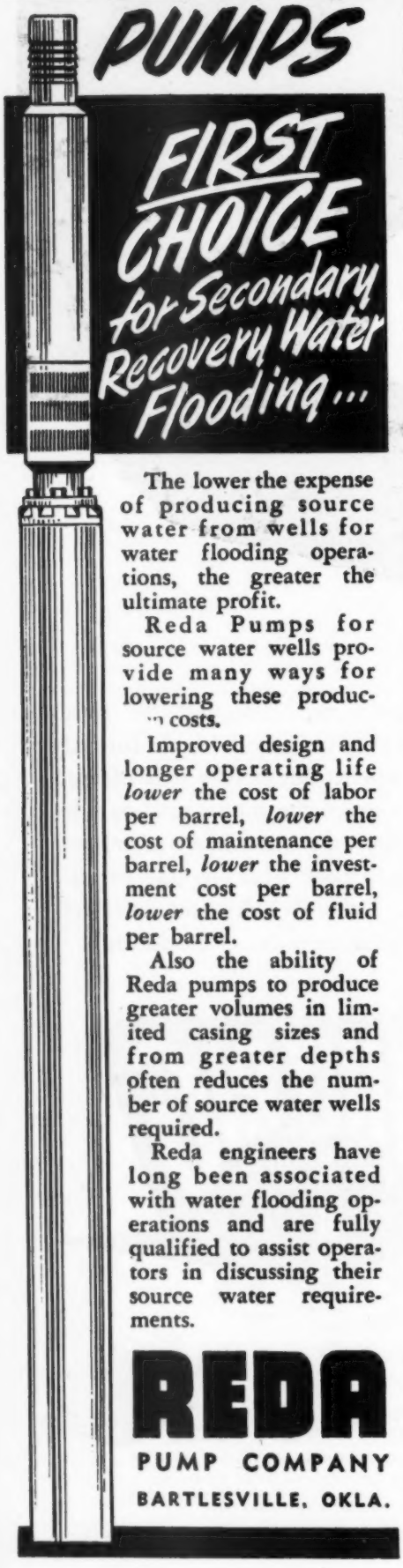

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power rig in the Castaic Junction field is shown in Fig. 9. Well A, off-setting the two jet-drilled wells, was the fastest conventionally-drilled well in the field by this rig. As near-maximum cleaning action by conventional watercourses was assured by parallel pump operations, this well provides excellent comparable data. A detailed comparison of bit data for Wells A and B indicates that a 225-ft-per-second jet velocity, created by three 5/8-in. nozzles, was necessary on Well B to effect an increase in penetration rate or footage per bit; this minimum velocity occurred at about 5000 ft. Well C, drilled with 20,000 to 25,000 lb bit weights and 100 to 150 rpm rotary speeds, successfully utilized three 9/16-in. and three 1/2-in. nozzles to maintain the average nozzle velocity above 250 ft per second and, in turn, extended the economical limit of jet bits to 8000 ft. The problem of availability necessitated substituting bits with three 5/8-in. nozzles for bits with three 1/2-in. nozzles at 7400 ft, which reduced the jet velocity to 220 ft per second and, consequently, prevented maximum improved performance although an average pump pressure of 1750 psi was maintained. Conventional bits were used from 8000 ft to total depth.

This rig has been equipped with 5-in. drill pipe for subsequent wells; however, as approximately the same bit weights and rotary speeds were used and maximum operating pump pressure for the 850-input-horsepower pump was reduced from 1800 to 1600 lb per sq in., based on a limited economic analysis, the hydraulic conditions have not been sufficiently improved at the bit to provide an additional increase in performance. These field tests confirm the theoretical data presented in Figs. 6, 7, and 8. Utilizing jet bits equipped with three 1/2 or two 5/8-in. nozzles, the pressure drop curves for 5000 ft indicate the circulating rate for 4 1/2-in. and 5-in. drill pipe would be about 575 gal per minute at 1800 and 1600 lb per sq in., respectively. In addition, Figs. 7 and 8 show that approximately 600 hydraulic horsepower is required with 4 1/2-in. pipe; whereas only 550 hp must be developed with 5-in. drill pipe. Referring to the respective graphs in Fig. 6, it is evident that each condition results in the same relative drilling rate of 43; this would be suspected as no change has been effected at the bit.

Principal advantage of the 5-in. drill pipe in this case is the reduction in pump pressure at the same circulating rate, and therefore, decreased pump repair costs. It is interesting to note from Figs. 7 and 8 that at 10,000 ft, the difference in pump pressures would be 1825 and 1525 or 300 psi for the respective drill pipe sizes at a reduced circulating rate of 500 gpm.

A heavy power rig, also in the Castaic Junction field, has recently justified torque converters which have been installed on the three engines driving the drawworks and tail pump, thereby materially improving the effectiveness of the hydraulic system. This rig parallels two 500-input-horsepower pumps and maintains 1200 to 1500-lb-per-sq-in. circulating pressure for both jet-type and conventional bits; current practice is to utilize jet bits to approximately 4500 ft.

Optimum conditions for jet bit drilling to maximum depth have been limited because of deviated hole and directional control requirements in some of the major fields such as Ventura Avenue. Inaccessible locations caused by mountainous terrain in parts of this field have justified drilling several wells from a single-surface location. As it is a practice of some of the operators to permit normal drift tendencies until directional work is started, usually between 5000 and 7000 ft, bit weights just short of the balling-up point have been possible. Data obtained from three comparable wells, drilling from an "island" by the same heavy power rig, are shown in Fig. 10. An average 75-per cent increase in drilling rate with a 100-per cent increase in footage per bit was effected by better utilizing the same hydraulic horsepower and reducing hole size. Although directionally drilled hole prevented an accurate evaluation below 6300 ft on Well D, other operations have indicated that improved bit performance can be expected at 10,000-ft depths if the hydraulic capacity is increased proportionally.

Many of the operators have recognized the advantage of a properly designed hydraulic system and used sound foresight in repairing or replacing present rig equipment. Although the hydraulic advantage of larger drill pipe can reduce drilling time materially at the greater depth, the increased weight would also decrease the maximum depth currently attainable by the drawworks. As this limitation would particularly restrict many of the medium power rigs with hoisting capacity already overloaded, some of the operators have chosen to increase the pump capacity as the first step of this long-term program. Torque convertors have been installed on several of these pump installations to better utilize increased capacity of prime movers and to act as shock absorbers for any excessive loads. Comparative data from the Rosecrans field for a rig with this type hydraulic design using a 7 3/4 by 18-in. pump reveal that the 5400 ft below surface casing to coring depth was drilled with 9 7/8-in. jet bits in approximately 45-per cent less rig days and 40-per cent less bits than two conventionally drilled offsets.

Parallel pump operations of the smaller 14 and 15-in. pumps have enabled many of the medium rigs to drill the top 5000 ft in the same time normally required by a single-pump operation on heavy power rigs. The advantage of this increased hydraulic horsepower has been apparent in the Rosedale field, Fig. 11, for both conventional and jet watercourses. The rig days, shown in the table, are a summation of the time expended between spudding and reaching coring depth at about 5500 ft and includes setting surface casing. Wells J, K, and L were drilled by the same medium rig; Well M was drilled by a comparable rig with a slightly

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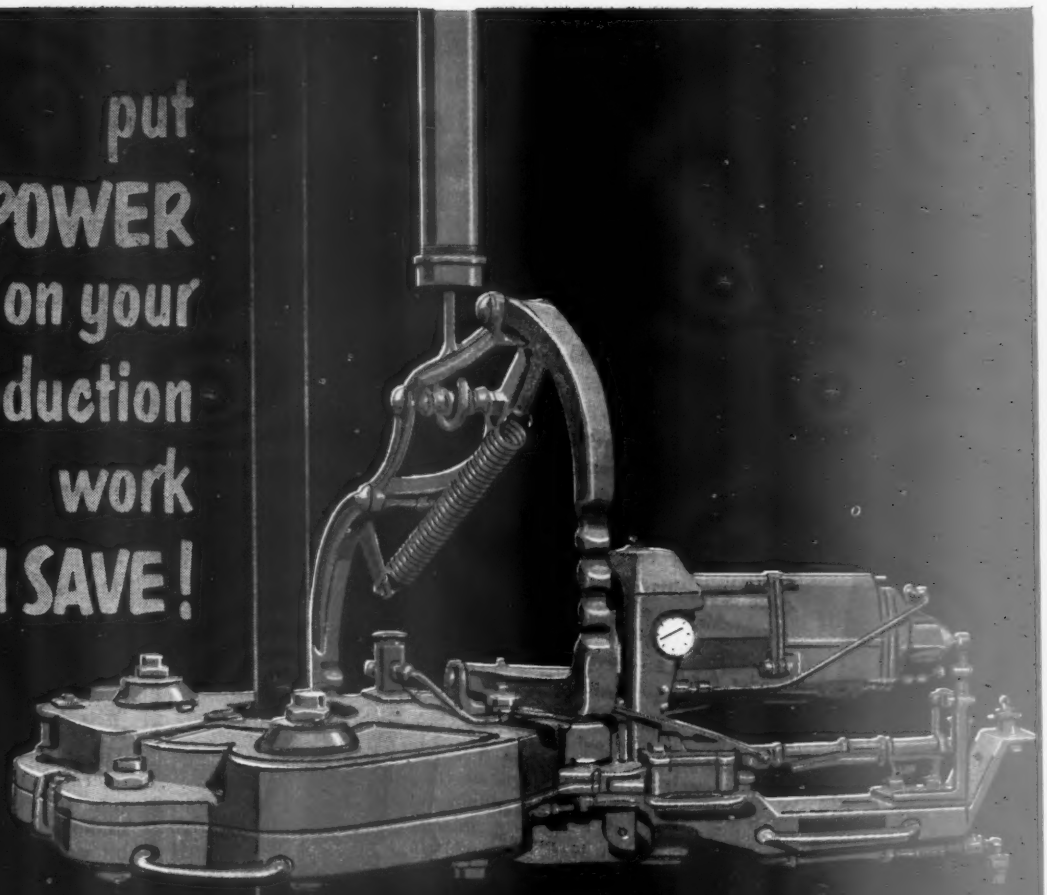

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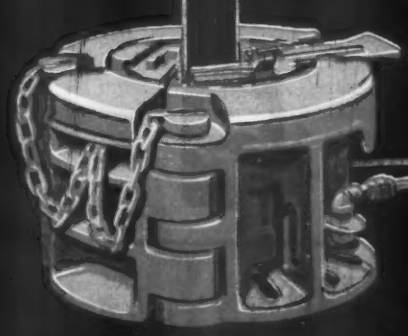

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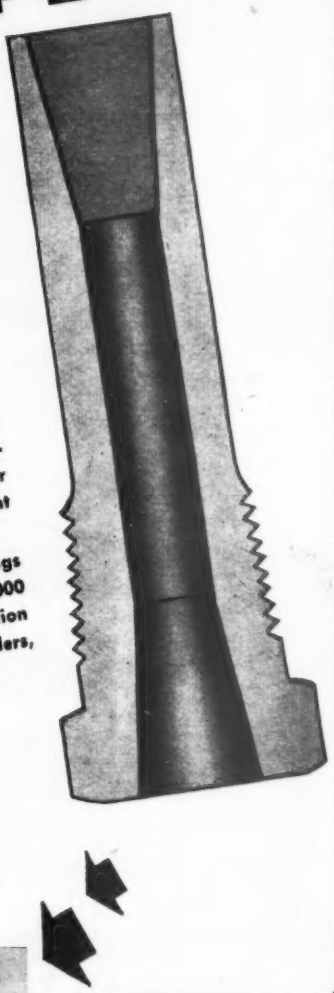

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½" x 2¾"	1087	6 oz.
½" x 3½"	1081	8 oz.
¾" x 2¼"	1091	8 oz.
¾" x 3"	1085	10 oz.
¾" x 3" Lg. Thd.*	1097	10 oz.
¾" x 4"	1079	12 oz.
¾" x 4" Lg. Thd.*	1095	12 oz.
1" x 2-3/16"	1089	12 oz.
1" x 3"	1083	13 oz.
1" x 4'	1077	16 oz.

*1¾" Thread length

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greater hydraulic capacity. Parallel pump operations with conventional bits on Well K permitted an increase in the effective bit weight and, therefore, substantially increased the drilling rate when compared with the performance of the partially balled-up bits on Well J. The use of jet-type bits and parallel pump operations to about 4000 ft on Well L permitted an additional increase in bit performance. Below this depth, however, the 190 to 200-ft-per-second nozzle velocity developed with a single pump apparently was not sufficient to keep the bit clean.

Conclusions

Current applications of high velocity jets have generally affected improved bit performance on all rig sizes having adequate hydraulic capacity. The economical depth to which they may be run is dependent on the proper utilization of the available rig equipment. A comparison of comparable jet-type and conventional rock bit data indicates that not only an improvement in drilling rate is obtained, but that an increase in footage of jet-type bits, approximating 30 to 50 per cent, may also be expected. The latter may be more significant to the operator than an increase in drilling rate in extremely hard formations or under circumstances where very light bit weights are required.

In using jet-type bits in the jet-drilling technique, the drill pipe size, hole size and mud pump capacity must be taken into consideration in selecting the correct nozzle size. Most bit manufacturers have sufficient pressure loss data and a practical knowledge of pump equipment to assist the operator in effecting a workable jet-type bit program; however, since the position of their representative is primarily that of service, it remains the operator's responsibility to ascertain the most economical application of the available equipment.

A study of single and parallel operations for the larger-size pumps in California indicates that there is a noticeable increase in pump repairs when the circulating pressures exceed 1500 to 1600 lb per sq in.; currently, drilling crews are not agreeable to operating pressures in excess of 1800 to 1900 lb per sq in. Assuming from these observations that 1800 lb per sq in. is the maximum economical pressure, it is evident from Figs. 7 and 8 that 600-output-horsepower pump capacity, 800-input-horsepower based on 75-per cent efficiency, is about the optimum requirement for heavy or extra heavy power rigs on the West Coast.

Tabulated data relative to the economic application of jet bit drilling technique in representative areas of the state are shown in Figs. 9, 10, and 11. The sales record for jet-type bits, graphically shown in Fig. 12, illustrates the progress of this new drilling technique in California. As indicated by the bit type, the majority of the jet-type bit operations are above 6000 ft for most rigs. Although jet bits have become a routine practice on many power rigs in California, it is evident that ultimate

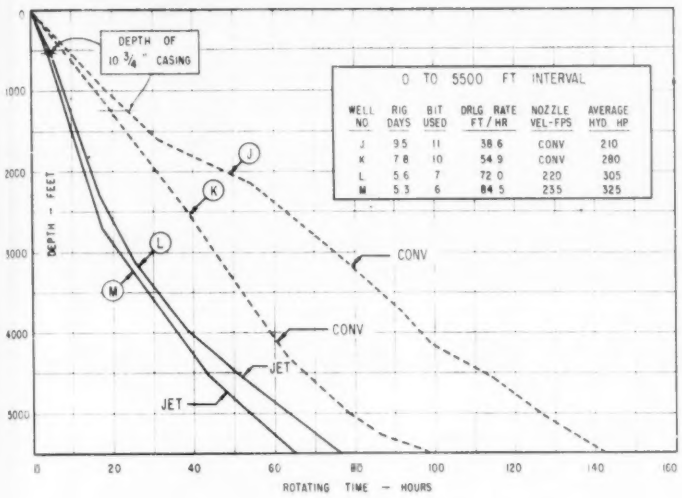
DEPTH OF 10 3/4" CASING
0 TO 5500 FT INTERVAL
WELL NO. | RIG DAYS | BIT USED | DRLG RATE FT/HR | NOZZLE VEL-FPS | AVERAGE HYD. HP
J | 9.5 | 11 | 38.6 | CONV | 210
K | 7.8 | 10 | 54.9 | CONV | 280
L | 5.6 | 7 | 72.0 | 220 | 305
M | 5.3 | 6 | 84.5 | 235 | 325
CONV
CONV
JET
JET
DEPTH - FEET
ROTATING TIME - HOURS

FIG. 11. Comparison of 9⅞-in. jet and conventional rock bit drilling at Rosedale field.

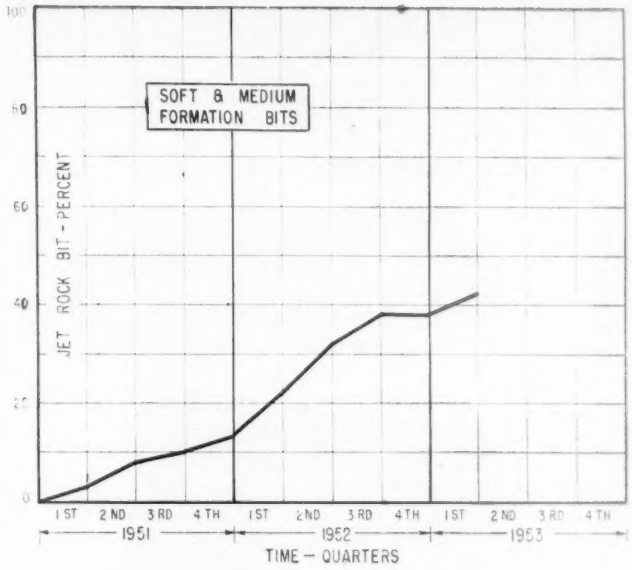
SOFT & MEDIUM FORMATION BITS
JET ROCK BIT - PERCENT
1ST 2ND 3RD 4TH 1ST 2ND 3RD 4TH 1ST 2ND 3RD 4TH
1951
1952
1953
TIME - QUARTERS

FIG. 12. Sales record of 9⅞-in. and 10⅝-in. jet rock bits in California.

efficiency has not been attained and that the present bit performance at increased depths can be substantially improved by a persistent and pracical approach to the development of jet-type rock bit drilling technique.

Acknowledgment

The drilling practice section of the California area sincerely appreciates the help and fine cooperation from Loffland Brothers Company, Drilling and Exploration Company, Inc., Miller and York, Santa Fe Drilling Company, Thomas P. Pike Drilling Company, Shell Oil Company, Camay Drilling Company, and other operators, as well as bit manufacturers who gave invaluable assistance in procuring data concerning field application of jet bits in California. Acknowledgement is also made to the Humble Oil and Refining Company for permission to publish this paper.

References

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2. "An Analysis of Hydraulic Factors Affecting the Rate of Penetration of Drag-Type Rotary Bits," by John R. Eckel and J. P. Nolley, Humble Oil and Refining Company, Southwestern District, American Petroleum Institute Meeting, Galveston, Texas, March 1949.
3. "Mud Flow in Drilling Mud," by R. J. S. Pigott, Eleventh Mid-Year Meeting, American Petroleum Institute, May 1941.
4. "Nozzle Design and Its Effect on Drilling Rate and Pump Operations," by John R. Eckel and W. J. Bielstein, Humble Oil and Refining Company, Southwestern District, American Petroleum Institute Meeting, Beaumont, Texas, March 1951.
5. "Factors Affecting the Rate of Penetration of Rock Bits," by W. J. Bielstein and George E. Cannon, Humble Oil and Refining Company, Southwestern District, American Petroleum Institute Meeting, Dallas, Texas, March 1950.
6. "How to Use Jet-Nozzled Rock Bits to Get Best Performance and Efficiency," by L. L. Payne and R. H. Nolley, Hughes Tool Company, 22nd Annual Meeting, North Texas Oil and Gas Association, Wichita Falls, Texas.

★ ★ ★

Comments by J. W. Speer
Ventura, California

The jet-type bit probably is the most significant recent advancement in the drilling industry. Thompson and the Humble Oil and Refining Company are to be complimented for their contributions to its development.

As pointed out in Thompson's paper, the jet bit is not a "cure all" for drilling progress, nor can "cut and dried" rules for its application be defined for all drilling conditions. With experience, however, general requirements for effective applications under a variety of conditions are becoming apparent, and additional experience should more clearly define these requirements as well as the full value of the jet-type bit to industry in terms of dollars per foot drilled.

Our experiences with the rock-type jet bit also indicate that the criteria for effective application are nozzle fluid velocity and circulating rate. Some improvements in drilling performance have been obtained with nozzle fluid velocities as low as 175 ft per second. Above 175 ft per second, drilling performance apparently varies directly with nozzle fluid velocity up to velocities of 275 to 350 ft per second. Above this upper limit, the effect of nozzle velocity apparently decreases, particularly in drilling the harder formations. Circulating rate, inasmuch as it contributes to the impact forces at the bit and to the removal of cuttings up the hole, is also a limiting factor. Some applications of jet bits have been made effectively using annular return velocities as low as 100 ft per minute. About 150 ft appears to be adequate, though perhaps not ideal, for most of California drilling.

Drilling weight also is a very determining factor in the performance of any bit and particularly so in the application of the jet bit because, to fully utilize the advantages of better bottom-hole cleaning and reduced tendency of the bit to "ball-up," drilling weights should be increased accordingly. A large part of the improvements obtained with jet bits have been as a result of increased drilling weight practices. Drilling weights of 30,000 to 40,000 lb on 9⅞ and 10⅝-in. bits are not uncommon, even in relatively soft 150 to 200-ft-per-hour drilling. Some recent experience indicates that these weights can be used in conjunction with rotary table speeds as high as 400 rpm without prematurely damaging the bit, although these studies are not advanced far enough to determine the advantages, if any, of these high rotating speeds.

Although substantial improvements have already been effected with the jet-type bit, a need for additional experience to define the many variables that affect performance is clearly indicated. Continued research similar to that presented by Mr. Thompson will undoubtedly provide further improvements.

Comments by J. K. Kellogg
K. L. Kellogg and Sons

This paper is an interesting adjunct to other published technical papers dealing with jet bit drilling, especially that portion that pertains to the practical application of fluid hydraulics. Generally speaking contractors allow their drilling superintendents or tool pushers to select this type and kind of bit used on a drilling rig. A practical paper such as this is of extreme value to them, as it is felt that many of them have been discouraged and frustrated with the theoretical aspects of fluid hydraulics. It is unfortunate that there isn't any simple way of selecting the proper nozzle and liner size for maximum performance in jet bit drilling. Present methods are unwieldly, and often result in improper applications with resultant unsatisfactory results and criticism of the entire jet program. A simple chart or device is needed in the field, for the tool pusher to determine the correct relationship of the hydraulic

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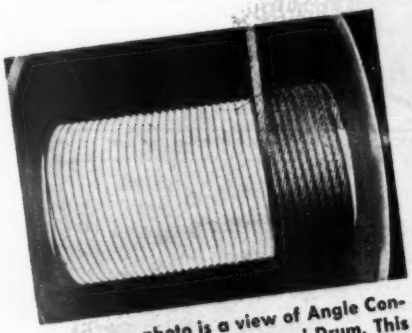
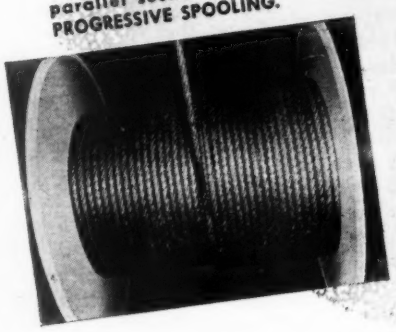
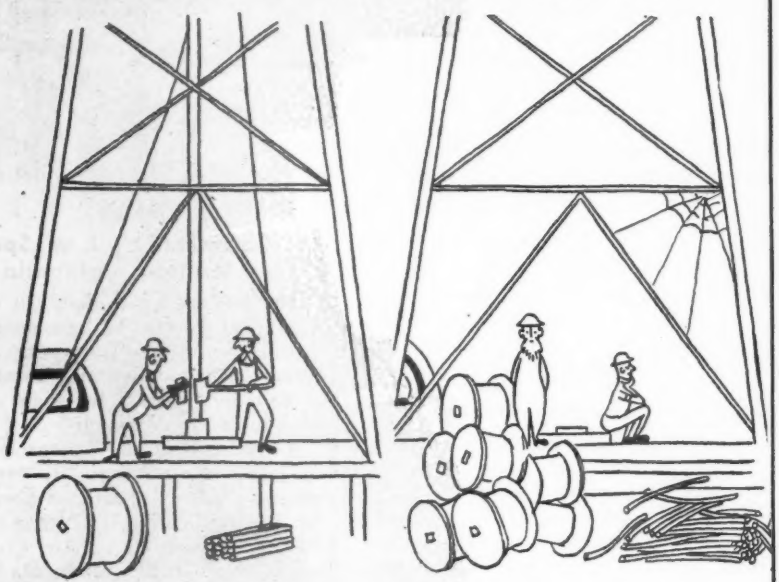


The above photo is a view of Angle Control Section of LeBus Grooved Drum. This illustrates the load being picked up with only 8 to 15 wraps of line on drum, requiring 100' to 200' less wire line in spooling system. Below is photo showing third layer of line being wrapped on parallel section to further illustrate PROGRESSIVE SPOOLING.



Saves Time and Wire Line



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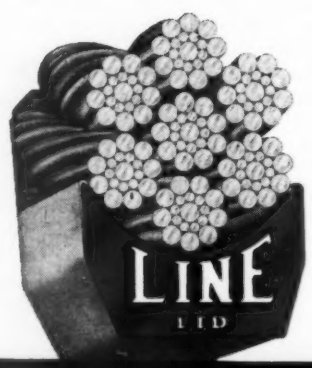

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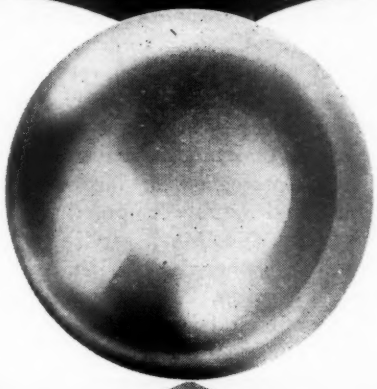

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system. An experimental step has been taken in utilizing a slide rule or set of tables, whereby a drilling rig is hydraulically rated with the only variables being the size and depth of the hole. Once these two variables are known, then the nozzle size can be directly read from the chart. This will be of great value to the field and sales personnel who seem to have the same lack of understanding.

It is unfortunate that the expression "jet bit" was coined, as many have expected tremendous increases in drilling rates without making any other changes in their hydraulic systems. Increased drilling rates experienced by others, however, and the normal course of competition, has convinced those earlier skeptics than an improvement is possible. They have subsequently modified their hydraulic equipment to gain the proper utilization of mud pump horsepower, which is the principal requirement of jet bit drilling.

Most jet bit drilling data have come from drag jet bit drilling, which is the exception rather than the rule in California. Our own company's experience, however, has been satisfactory using jet bits in hard formations. A large measure of this success has been due to removing cuttings from the teeth of the bit and their immediate removal due to the increased nozzle velocities. This also seems to give an increased number of hours on bottom with the same bit, which is advantageous. The maximum advantage in using jet bits is often hard to realize, due to the necessity of more weight on the bit. In many areas this will cause a crooked hole which adds an entirely new problem in the realm of stabilizing the drilling assembly or using larger diameter drill collars. Holding up on the bit and turning at an increased rate of rotation, undoubtedly results in wearing out the formation rather than chipping and fracturing it. This procedure, unfortunately, seriously retards rate of penetration, but is often only solution in straightening a hole.

The charts the author has used in comparing jet bit drilling with conventional bit drilling, generally parallels our own experience. It is true, however, that in drilling consecutive wells in any one field and regardless whether jet or conventional bits are used, an increased rate of penetration is obtained in each successive well. This is largely due to the increased efficiency or "breaking in" of the crew, and more first-hand knowledge of the formation breaks and field characteristics.

The application of fluid hydraulics has assisted in the general design and engineering of drilling rigs. It has focused attention to the bottom of the hole where the actual drilling is taking place. We have been able to specify what speed of rotation is desired, how much weight is desired on the bit, and the pressure and volume desired at the bit nozzle. All this can be combined with the result being a better balanced rig, which, in turn, will give us an increased rate of penetration with lower cost to the operator, which is the crux of any successful technical advancement. ★ ★

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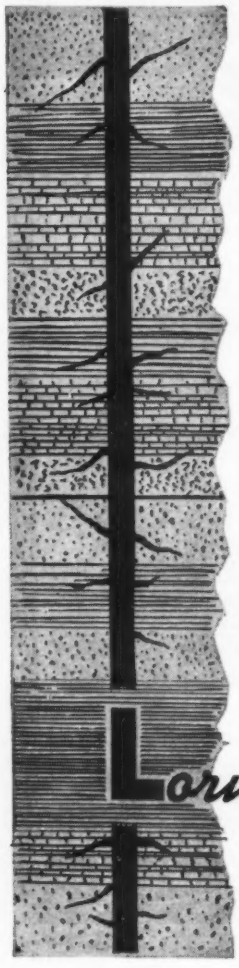

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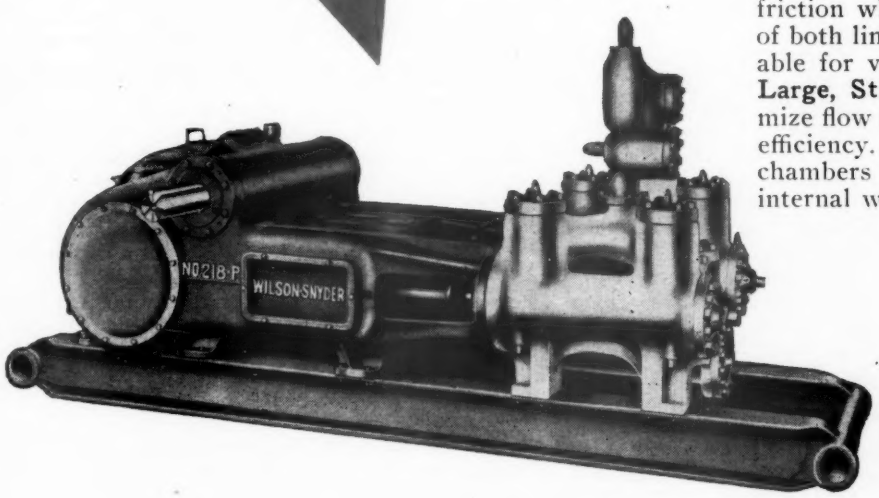

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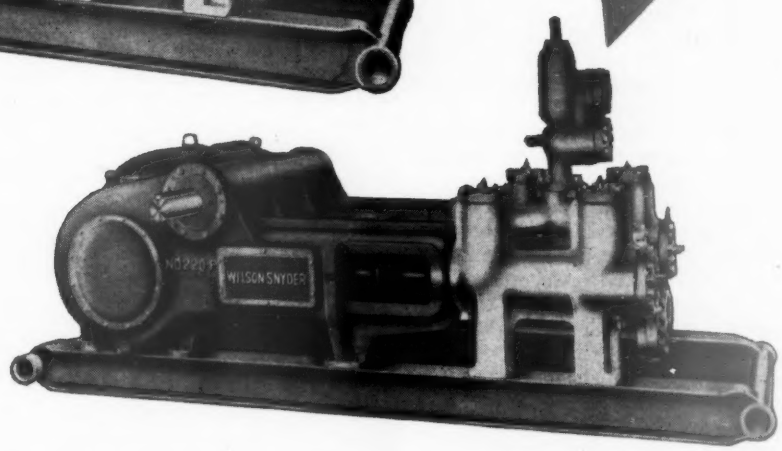

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AIME FIELD TRIP. Enjoying refreshments after their box lunch at Humble's lease in the Castaic Junction field are Hal Stanier, Sunray, chairman of the field-trip committee; and Russ Wade, in charge of the program. Lunching at Humble's Castaic Junction lease were: Front row, C. H. Holliday, Bob Phelan, Bob MacAlister, and Dan Foss, all of Shell. Back row: John Thacher, Standard of California; Charles R. Dodson, U.S.C. professor; H. W. Slattery, Stanley, Stolz and Dodson; John Bell, Humble; Alex Williman, B-J Service.

SEG Moves to New Offices

Headquarters offices of the Society of Exploration Geophysicists have been moved to the Elm Oil Building at 624 South Cheyenne, Tulsa, Oklahoma, it was announced by Colin Campbell, business manager. The offices were moved from a suburban Brookside location to larger downtown quarters this month on the recommendation of a committee of Tulsa members headed by Dr. Karl Dyk of Stanolind Oil and Gas Company, vice president of SEG. E. V. McCollum, of E. V. McCollum and Company, past secretary-treasurer of the society and Paul L. Lyons, of Anchor Petroleum Company, former SEG editor, served on the committee.

New Shell Oil Office Set Up in Salt Lake City

Salt Lake City has been chosen by Shell Oil as the headquarters for a new Salt Lake City division now being established to conduct the exploration and production activities of the firm, according to an announcement by S. F. Bowlby. Los Angeles, vice president of the Shell Oil Company.

Management staff for the new division, according to Bowlby, will include G. H. Sturgeon, senior geologist from the Los Angeles office, as division exploration manager and J. E. Mohr, district land agent from Grand Junction, Colorado, as division land manager.

The new division will be under the jurisdiction of the Pacific Coast area office in Los Angeles and will supervise the activities of several districts.

The Salt Lake district already established here with W. M. Woodward as district geologist will continue to function under the new division and will be expanded to include the Great Basin area of Western Utah and Nevada.

Additional appointments by Bowlby to senior staff positions in this area include Arthur L. Brown, formerly with Shell in Ventura, California, as division exploitation engineer; and M. H. Harvey, also of Ventura, as division office manager.

AIME Holds Field Trip

More than 200 members of the Pacific Petroleum Chapter of the American Institute of Mining and Metallurgical Engineers and their guests spent one day recently touring oil fields around Newhall and Castaic Junction, California, an area that is contributing substantially to California's growing crude production.

During the all-day trip the 50-car caravan visited Honor Rancho, Castaic Hills, Oak Canyon, Del Valle, Castaic Junction, Placerita, Newhall-Tunnel area, Newhall-Potrero, and Pico Canyon. In addition talks were given on other nearby fields, including Torrey Canyon, Oakridge, and the Tapo Canyon fields.

Hal Stanier, Sunray Oil, headed the field trip committee. Other members were: Herm Schaller, McClulough Tool; Russ Wade, Union Oil; Kemp Barley, Baroid Sales division; and Chuck Evans, Schlumberger Well Surveying.

Saudi Arabian Report

Crude oil production in Saudi Arabia during June amounted to 26,426,815 bbl, or an average of 880,894 bbl per calendar day, it was announced by the Arabian American Oil Company.

Crude oil production for the first six months of 1953 amounted to 151,048,579 bbl, an average of 834,523 bbl per calendar day.

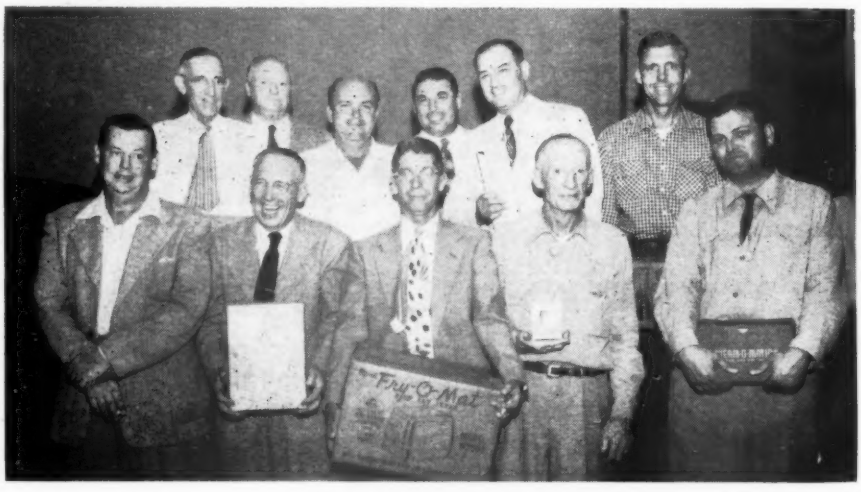
IPAA Headquarters Underway

Construction of a modern one-story office building to house the national headquarters of the Independent Petroleum Association of America got underway in Tulsa, Oklahoma, recently.

It will be an L-shaped building, 116 ft long and facing 103 ft on S. Boulder Avenue, just outside Tulsa.

A building committee, appointed from the IPAA membership to plan the new headquarters, was headed by Fred W. Shield, San Antonio, Texas, a past president of the association.

DOOR PRIZE winners at the LA Nomads Whing Ding, were: Back row, Ray Myers, Continental Supply; Babe Doyle, Hydril, Prize Committee; Ralph Ruse, Diamond Drilling; Ox Morgan, Oil Well Manufacturing, in charge of Whing Ding Committee; Leo Theisen, Falcon Products; Gilbert Wilson, Gulf Publishing. Front row, Joe Adams, Havenstrite Oil; Neil Carmichael, Sargent Engineering; Knight Templeton, S. R. Bowen; W. M. Zigler, H. C. Smith Oil Tool, and R. V. Wildman, Abegg & Reinhold.



Geologists Plan Annual Meeting in St. Louis

The 39th annual meeting of the American Association of Petroleum Geologists will be held next April 12-15 in St. Louis, Missouri, Graham B. Moody, convention general chairman, announced in disclosing status of arrangements for the yearly event.

Moody, Standard Oil of California, San Francisco, said that technical programs will be held in the Opera House and commercial and educational exhibits displayed in the Convention Hall of St. Louis' Kiel Auditorium. The Jefferson has been designated the headquarters hotel.

The convention is held jointly with the Society of Exploration Geophysicists and the Society of Economic Paleontologists and Mineralogists.

Century Purchases Drilling Company

Formation of Century Drilling Corporation has been announced by Ben F. Rummerfield, vice president of Century Geophysical Corporation, Tulsa, Oklahoma.

Rayburn Drilling Company, a seismic shot hole drilling company, was purchased by Century, and Floyd H. Rayburn, president of the former company, will manage the new drilling company as supervisor of drilling operations.

Century Drilling is operating shot hole drills in New Mexico, Wyoming, North Dakota, Montana, and Texas.

Officers of Century Drilling are: Opie Dimmick, president; Ben F. Rummerfield, executive vice president; David R. Weichert, vice president and James B. Bender, secretary-treasurer.

Field Conference Planned For Geological Society

The fourth annual field conference of the New Mexico Geological Society will be held on October 16-18 in southwestern New Mexico. Registration will be in El Paso on Thursday, October 15, and there will be a short excursion into the Franklin Mountains near El Paso that afternoon. Conference caravan will assemble in Las Cruces on October 16, and disband in the Chiricahau Mountains, Cochise County, Arizona, on October 18. Outcrops of Paleozoic, Mesozoic, and Cenozoic sedimentary rocks in this critical wildcat province will be visited, and emphasis will be placed on the Grant County, New Mexico, mining districts.

Field conference chairman is Edward C. Beaumont of the U. S. Geological Survey in Albuquerque, and the guidebook editor is Dr. Eugene Callaghan of the New Mexico Bureau of Mines and Mineral Resources.

TU Schedules Graduate Seminary in Geology

Some of the nation's outstanding geologists and petroleum industry leaders will be guest lecturers this fall at the University of Texas.

They will discuss technical and ethical aspects of careers in geology during a special graduate seminar, Dr. S. P. Ellison, Jr., geology department chairman, announced.

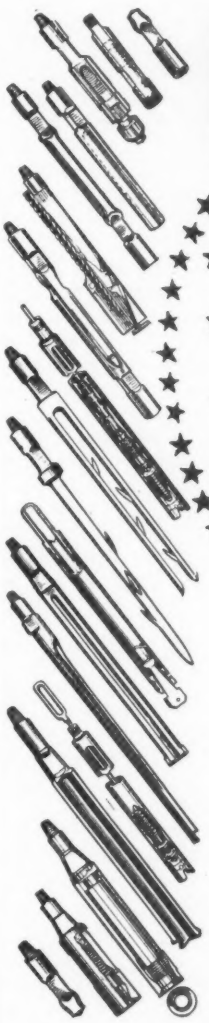
Edgar W. Owen, San Antonio geologist and former president of the American Association of Petroleum Geologists, will direct the seminar, which will meet each Tuesday and Thursday of the first semester.

Speakers will include L. F. McCollum, Continental Oil president, and L. T. Barrow, Humble Oil and Refining board chairman, both of Houston; E. L. De Golyer, geologist, and F. H. Lahee, former chief geologist, Sun Oil, both of Dallas; Wallace E. Pratt of Frijole, retired vice president of Standard of New Jersey; George G. Simpson of New York City, American Museum of Natural History executive.

H. H. Bannerman, chief geologist, and Earl Ingerson, senior geologist, both with the U. S. Geological Survey; C. C. Gillespie, Princeton University history professor; and Cary Croneis, now president of Beloit College, Beloit, Wisconsin.

University of Texas faculty and staff members scheduled to speak during the seminar include: S. E. Clabaugh, R. L. Folk, J. A. Wilson, R. K. DeFord, John T. Lonsdale, and Ellison.

The University will record the lectures, which will be edited by speakers and by Owen and published in book form.



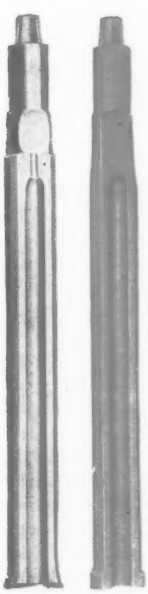
YOUR U. S. A.

If someday you and I wake up to discover that our American free system of business, industrial, and individual enterprise is gone forever, don't blame the politicians. They will have done only what we have permitted them to do.

Nowhere else have men enjoyed the individual dignity, personal freedom and unlimited opportunities for educational, cultural and material advancement that have been ours as a society of free people supporting free institutions in the American tradition. If the paternalistic meddling of professional crackpots and irresponsible theorists, posing as champions and oracles of foreign ideologies, sell us down the river, it will be our own fault.

So, don't blame the politicians.

Remember—We elect them!



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What's Doing in Drilling

WYOMING

★ Stanolind Gas and Oil Company is preparing for completion attempt in their No. 2 Middle Mountain unit, Sweetwater County, after two promising drill stem tests of the Mesaverde zone. A reported five million feet of gas per day from the zone 6525-6535 was recovered on the first test and a stem recovery of 150 feet of clean oil was reported from the second test made in the interval 6536-6548.

NORTH DAKOTA

The Tioga field gained a one mile extension to the northeast with the completion of the Rudman No. 3 Hanson. The well yielded free oil on test between 8252 and 8282, drill stem recovery being 300 ft of oil and 300 ft of oil cut mud.

TEXAS

★ The discovery of a new producing horizon in the White Flat field of Nolan County in American Trading and Production Corporation's No. 2 Little is one of the more significant development items of the month. Drill stem test of the Wilbern's Dolomite which was encountered under the lower Strawn with a top of 5482 in the inteval 5482-5522 yielded oil at the surface in 14 minutes flowing a full, heavy stream. Flow was halted prior to gaging due to the fire hazard. Flowing bottom hole pressure of 1575 lb indicated excellent permeability in the section tested. Drilling was continued to 5601 where the base of the 119 ft, fully saturated Dolomitic section was recorded. Hickory sand was penetrated from 5601 to 5613 and this interval was drill stem tested with results similar to that obtained from the Wilbern. Oil water contact in the Hickory was established at 5625. Drilling will proceed until the pre-Cambrian granite is encountered.

★ In Crocket County the Continental Oil Company has completed two producers in the Elk Horn Ellenberger field. No. 2-27 University was finaled with an IP of 775 bbl of 40.5 degree oil, no water, on a 34/64 in. choke from perforations between 7256 and 7296. This well had previously been tested in the Crinoidal section of the Pennsylvanian yielding 31 bbl of oil per hour through drill stem.

★ Conoco's 7-D University in the same field was completed with an IP of 1031 bbl of 30.4-degree oil through a 35/64 in. choke from perforations between 7360 and 7390.

★ North of Houston in Harris County the Harrell Oil Company reports an IP of 135 bbl per day through an 12/64 in. choke from perforations between 6791 and 6794 feet in the No. 1 L. L. Strey in the South Bammel field. Flowing tubing pressure was 1270 lb and the gas-oil ratio 444-1.

★ In Colorado County, 10 miles south of Sheridan, an apparent one and one third mile extension of the Garwood field is seen in the reported completion of Johnny Mitchell No. 1-C. A. Bass as a gas well. Completion gage has not been reported.

★ Texas Eastern Production Corporation reports the completion of the No. 1- C. B. Fasken for an IP of 414 bbl of 44-degree oil. Located over half a mile southeast of the Magutex field of Andrews County, the No. 1 Fasken was completed in the Devonian through perforations 12,486-12,490. Potential test was made through a 24/64-in. choke.

★ Also in Andrews County Continental's No. 2 McCollum and Weibusch extends the McCollum Wolfcamp field to the south with an indicated daily potential in excess of 1200 bbl per day. Test was made through a 1 in. choke from perforations 8917 to 8927 and 8988 to 9014 after section had been treated with 1000 gallons of acid.

★ In Dawson County Cities Service Oil Company has completed its No. 2 Brennand in the Wolfcamp reef for an IP of 482 bbl per day. Top of the reef was reported at 8544 with total depth of the well 8607. This completion provides a quarter mile east extension to the Mungerville field.

★ Newton County in Southeast Texas has received a significant completion in Warren Petroleum Corporation's No. 1 B. E. Quinn. Producing from the interval between 7360 and 7374 the well was given an IP of 200 bbl of 45-deg oil per day through a 13/64 choke.

MISSISSIPPI

★ The Gulf No. 1 Chapman Smith unit has extended production in the Chaparal area in Wayne County by completion in the Eutaw zone through casing perforations from 4313 to 4317. Well will apparently be completed as a pumper. Reported crude gravity was 16.9 deg.

★ In the Soso field of Jones County, Gulf Refinery Company No. 1 Bailey set pipe at 12,207 feet and flowed through perforations 11,987 to 11,990. Initial gage was 218 bbl of 40-deg oil on drillstem test.

CALIFORNIA

★ Standard Oil Company of California has plugged back its No. 43 KCL-33 to 4048 ft for completion attempt. On drill stem test the interval of 3990-4047 flowed 38-deg oil at a 1000 bbl daily rate. This well is situated in the Wheeler Ridge field of Kern County and apparently confirms another new pool.

★ In Orange County Drilling and Exploration Inc. has completed its No. 2 State Stern in the Richfield-Atwood area. Pumping about 350 bbl daily, fluid showed 20 per cent water from the Kraemer zone from 4350-5043 ft. Gravity is in the 20-deg range.

★ In the Leffingwell area, Los Angelos County, two pool extension completions are announced. Signal Oil and Gas Company completed their No. 1 Stern for 100 bbl pumping and Hathaway completed their No. 2 Woodward as a flowing well. Both wells produced from the 8600-ft sand.

LOUISIANA

★ Kerr McGee Oil Industries Inc., have completed its offset confirmation well in Block 29 of Breton Sound. Their No. 1B State lease 2000 flowed on a small choke at a rate in excess of 200 bbl per day from casing perforations between 5858 and 5874 with no water.

★ In the Pointe a la Hache field, Richardson and Bass have completed a significant one-mile southeasterly extension well. The No. 1-E Humble-Haskel Davis unit B was tested from perforations 11,361 to 11,366 yielding 150 bbl of 34-degree oil per day with a flowing tubing pressure of 1600 lb.

★ The Church Point field in Arcadia Parish has been extended by the completion of the Pan American No. 1 Stafford. IP was 50 bbl of 60.8-deg condensate with 2,500,000 cu ft of gas. Test was of section 10,330 - 10,338 flowing through a 12/64-in. choke with a tubing pressure of 3100 lb.

★ The Texas Company has extented the Sweet Bay Lake field of St. Mary Parish with their No. 1 State-Miami Corporation which tested 312 bbl per day on a 14/64 in. choke from 13,272 to 13,276.

Rotary Rigs Operating in Oil Fields of United States and Canada*

	July 13	July 20	July 27	Aug. 3	Aug. 10
Pacific Coast	171	170	172	170	170
Oklahoma	335	338	328	356	366
Kansas	162	165	167	169	159
Rocky Mountain	272	265	266	267	273
Canada	155	168	169	175	180
Ark-La-Tex	152	155	147	145	150
West Texas & New Mexico	495	468	463	463	467
Gulf Coast	552	557	565	577	570
Illinois	141	154	156	158	152
North Texas	335	332	327	319	329
Total	2770	2772	2760	2799	2816

*As reported to American Association of Oilwell Drilling Contractors by Hughes Tool Company.

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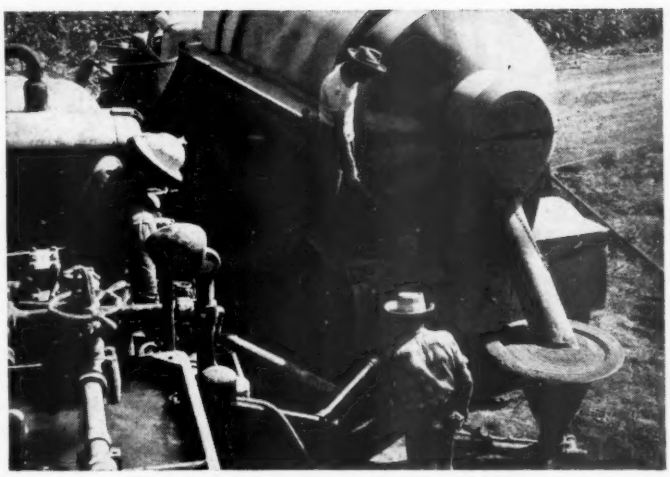

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PE-U-131

CANDA

★ The National Petroleum Corporation, Ltd., has announced completion from the Banff formation between 6134 and 6216 of their Northland-Regency No. 1. Subject well is a mile north of the Montana border in Alberta and is considered significant in that it has developed shallower production on a long anticlinal fold, previously produced from low permeability deeper horizons. The initial tests indicated a producing rate of 250 bbl per day on choke. Corrected gravity of production was 38.3-degrees.

★ Western Homestead Oils, Ltd., report their No. 6-26 Hudson in the West Hamilton Lake Area of Alberta yielded a small gas flow in 30 min and 780 ft of clean 33-deg oil on a two-hour drill stem test of the zone 2910-2955. Company is running pipe for completion of test.

There was also 60 ft of emulsified oil and mud.

★ In the Fosterton field of Saskatchewan, Socony Vacuum has completed their No. 10-1B Fosterton at 3211 and No. 3-8B Fosterton at 3191 as medium gravity oil producers and have started two more wells in the same area.

★ In Alberta, West Drumheller field, New Superior Oils of Canada have completed two more D2 formation producers. The No. 3-1 was completed at 2612 and flowed 912 bbl per day through a 1 in. choke. The No. 6-1 well was completed at 5592 ft and flowed 854 bbl daily through a 1 in. choke.

NEW MEXICO

★ Significant enlargements in New Mexico's productive capacity are noted with the recent completion in Lea County of three Gulf Oil Corporation wells with a combined production of 3949 bbl per day.

★ Gulf No. 3 Simpson extended the Denton "Devonian" field to the south and west with an IP of 2496 bbl 45 deg oil through a ¾ in. choke from perforations 12,465 to 12,535. Gas-oil ratio was 1256-1.

★ The No. 3 Davis completed with an IP of 840 bbl of 32 deg oil extended the East Hobbs (San Andres) pool to the west. Test was made through a ¾ in. choke from a producing interval between 4421 and 4443 ft with a gas-oil ratio of 526-1.

★ Extension of the West Dollarhide field one mile south was accomplished through the completion of Gulf's No. 29-A Leonard with a smaller IP of 713 bbl per day of 37 deg oil through a ¾ in. choke. Gas-oil ratio was 510 to 1.

★ Stanolind Oil and Gas Company in their No. 6 Wingerd in the Gladiola field, reports an IP of 334 bbl of 47 deg oil through a 9/64 in. choke from the Devonian.

★ In Chaves County, New Mexico, the Republic Natural Gas Company announces the completion of their second producer in the White Ranch field IP reported was 2598 bbl of 40 deg oil through a ½ in. choke with a gas-oil ration of 459-1.

DIFFICULT assignment is ahead for this American-made oil well drilling rig set up in New Zealand. It will drill for steam rather than oil and will encounter pressures up to 200 pounds per square inch and temperatures up to 400 F. Rig is a National Supply Unit powered by two GM Detroit diesel torque converter engines.

KUWAIT — SAUDI ARABIA

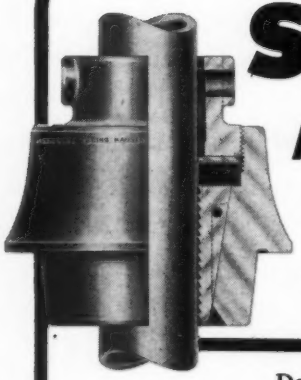
★ The American Independent Oil Company's second well in the newly discovered Wafra field is announced as having a sustained productive capacity of approximately 1500 bbl per day. Initial production tests show the well to have an initial capacity of about 3500 bbl per day. The third well has been located one mile east and one mile south of the recently completed extension.

OKLAHOMA

★ The announcement of the completion of the McMillan Petroleum Corporation's No. 2 Krout in Logan County adds a third producing zone to the field and constitutes a sizable extension to the reserves. Producing from a three-foot interval of the Layton sand at a depth of 5114, the well yielded 2,700,000 cu ft of gas and 60 bbl of 61 gravity distillate through a 20/64-in. choke in 20 hours with a pressure of 825 lb.

★ In Lincoln County the Sun Oil Company has completed its No. 4 Curry with a flow of 653 bbl of 51-degree oil in 13 hours through a ¾-in. choke from the Oswego lime at 3359.

★ Cities Service Oil Company's No. 1 Stansbury in Garvin County was perforated from 8976-9022 ft. The well flowed 278 bbl per day with a gas-oil ratio of 645-1 on a ¼-in. choke on completion.



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Exploration Activities

ARKANSAS

★ Tom Palmer, in his No. 1 Fouke Estate in Miller County has opened paluxy production through casing perforations between 4889 and 4898. IP was 115 bbl of 31-degree oil per day under pump.

★ In Columbia County the Murphy Corporation has completed its No. 1 Birtie as a flowing well. Production initially was 71 bbl of 42-degree crude per day through 12/64-in. choke from casing perforations between 7588 and 7598 ft.

OKLAHOMA

★ Continental Oil Company's No. 1 Pruitt has been completed in the Hunton lime in Carter County. IP was 200 bbl of 40-deg oil per day with 114,000,000 cu ft of gas through a ¼-in. choke from perforations 4576-4612. Gas-oil ratio was reported to be 570-1 with a flowing tubing pressure of 200 lb.

★ Magnolia Petroleum Company in its No. 1 Gladys Love, six miles southwest of Purcell, has a flowing Bromide sand oil discovery. Flowing 325 bbl of oil per day through a ½-in. choke with a gas-oil ratio of 656-1, this new field opener is producing from casing perforations between 8317-8377 ft. Gravity of the produced oil is 40-deg.

KANSAS

★ The Bishop Oil Company announces completion of its No. 1 Henderson in Pratt County with a flowing IP of 1596 bbl of 36-deg oil per day. Production is through casing perforations opposite the Viola chert in the interval 4236 to 4246 ft.

★ Morrison Drilling Company has drilled plug and is treating the Arbuckle lime in its No. 1 Harper in Pawnee County. A drillstem test of interval 4002 to 4024 ft recovered 2820 ft of oil in 1¼ hours.

TEXAS

★ Texas Eastern Production Corporation in Brazoria County has completed its No. 1 Rosa Clark as a gas discovery. Situated 4 miles southwest of Alvin the calculated opened flow potential of the discovery was 140,000,000 cu ft per day. Drilled to a total depth of 10,837, well was completed in the Basal Frio. Shutin tubing pressure is 8250 lb.

★ Completion by Magnolia Petroleum Company of the No. 1 C. B. Fasken has been announced. Flowing on a 24/64-in. choke, IP was 414 bbl of 44-deg oil per day. Bottomed at 12,609 ft in the Devonian and completed through perforations from 12,486 to 12,590, the well promises to be a substantial extension to the Magutex Devonian field in Andrews County.

★ In Fisher County, Caddo lime production has been assured in the B. M. Hester and Sons No. 1 Gena Dooley, completed as a flowing well. The IP was 360 bbl per day through ½-in. choke between 6786 and 6802 ft.

★ In northeast Texas, Red River County's first oil production was seen from the Seaboard Oil Company's No. 1 Coline. Testing through perforations from 4920-4926 in the Travis Peak formation, operator swabbed 135 bbl of 27-degree oil per day. Fluid level during swabbing remained around 1000 ft.

★ The Jupiter Oil Company's No. 1 M. E. Jackson-Hodges in Anderson County has been completed as a Rodessa discovery. IP of 400 bbl of 45-deg oil per day through a 12/64-in. choke was reported. Casing perforations are from 8975 to 8985.

FLORIDA

★ Interest in a Key Largo wildcat south of Miami being drilled by Sinclair has been hightened by slight shows and pin point porosity around 10,000 ft. Crew was reported coring at 10,608 ft and in the Sunnniland sand.

★ Humble has reported shows of oil in their W. E. Kirchoff No. 1 in Lee County. Seventy-five feet of oil in 37 hours with no gas to the surface during a test of the zone 11,819 to 11,928 ft was reported. Drilling continues.

MONTANA

★ Phillips Petroleum Company and Sun Oil Company are completing their No. 1 Dynneson, a Richland County wildcat. The well flowed 745 bbl of 48-deg oil per day through 20/64-in. choke following a 2000 gal acid treatment of the Red River formation through perforations from 12,585 to 12,605 ft.

WYOMING

★ The Houston Oil Company has reported an initial flow in excess of 100 bbl of oil per day at the No. 2 Burke Ranch unit of Natrona County. Production is from the Dakota between 6658 and 6672. Formation was acidized and fractured.

★ In Big Horn County Socony-Vacuum reported flow of 200-300 bbl of oil per day on test of its No. F-41-4-G, a southeast Manderson extension.

★ Completion of the Trigood Oil Company No. 1A Baker of Carbon County as a 225 bbl discovery well is announced. Test was made through a ¼-in. choke from the Sundance zone between 6900 and 6948 ft.

CANADA

★ The McIvor Drilling Company, Ltd., et al, in its No. 1 Roselea in southwest Manitoba have a flowing Mississippi oil producer. Drillstem tested from 2047-2101, the well flowed oil in 35 min with no sign of formation water at the conclusion of the test. Gravity of the crude was 34.8-deg. After completion in the same zone the well was gaged for an IP of 120 bbl per day.

LOUISIANA

★ Five miles northwest of Reeves in Allen Parish, H. J. Hunt in his No. 1 Perkins appears to have opened a new oil field. Completed flowing 123 bbl of 46.7-degree oil through a 8/64-in. choke, gas-oil ratio of 1563-1. Production is through casing perforations 8923-8927.

★ Curtis-Hankamer No. 1 Lutcher-Moore is announced as complete with an IP of 107 bbl of 40-degree oil per day with a flowing tube pressure of 1530 lb. Gas-oil ratio of 700 cu ft per barrel. Test was conducted on a 7/64-in. choke from a sand interval at 7632-7635.

★ In Claiborne Parish, Lyons-McCord and Logan No. 1 Meadors was gaged for an IP of 200 bbl per day through a 24/64-in. choke. Production is from casing perforations between 7762 and 7774 opposite the Bodcaw sand.

NEW MEXICO

★ Continental Oil Company No. 4 Andrews Ranch unit has been completed as a Wolfcamp discovery with an IP of 1758 bbl of 42-deg oil with a gas-oil ratio of 313-1. Production is through perforations between 9760 and 9828 after treatment with 1000 gal of acid.

★ Neville G. Penrose No. 1 Fair Weather unit in Lea County has been drillstem tested from 11,000 to 11,020 ft. Gas surfaced in 7 minutes and fluid in 1 hour. 58 minutes. The well flowed 6½ bbl of 43.5-deg crude per hour.

★ New Mexico's deepest well, the Richardson and Bass No. 1 George Cobb-Federal has been plugged back and completed as a discovery from the Delaware sand. The new Eddy County field opener produced 215 bbl of 40-deg oil and 35 bbl of water through perforations from 7003 to 7035 ft after fracture treatment with 3000 gal. Total depth drilled was 16,459 ft in granite.

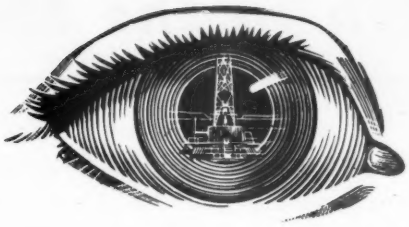
★ Forest Oil Corporation No. 1 Federal-General American was completed as a Pennsylvania discovery with an IP of 170 bbl of 42-deg oil in four hours on a ½-in. choke. Calculated daily potential was 1023 bbl with a gas-oil ratio of 495-1. Final perforations were in the Pennsylvanian between 7774 and 7860.

COLORADO

★ British-American Oil Company has announced the completion of a "highly productive" oil well in Logan County, two miles southeast of the Peetz field. The new well is a dual discovery in the D and J sands. The upper sand tested 3,500,000 cu ft of sweet gas, while the J sand, which contained 36 ft of oil bearing section, was rated as being capable of delivering 1000 bbl of high gravity oil per day.

★ The California Company at their No. 1 Baiamonte in the Black Hollow area of Weld County has recovered oil at the rate of 27 bbl per hour under swab without lowering the fluid level substantially.

XUM



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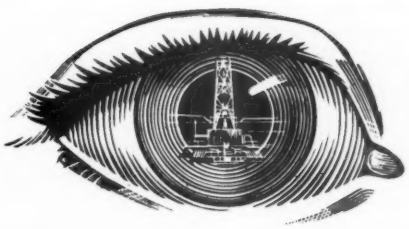

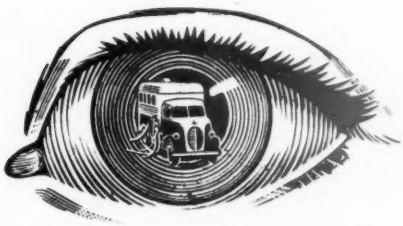

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Running Tour With Men in the Industry

Paul R. Turnbull has resigned as drilling and production manager for La Gloria Corporation in Corpus Christi Texas, to join the ranks of independent oil producers. He will be affiliated with B. F. Vaughan, Jr., and Frank P. Zoch, Jr., with offices in the Wilson Tower in Corpus Christi. In addition, Turnbull will now serve as president of Del Mar Drilling Company, of which he has been one of the owners during the past few years.

Turnbull was graduated from the University of Oklahoma in 1929. He then joined the Humble Oil and Refining Company, and for the following 19 years served in various areas in Texas. He joined La Gloria Corporation in 1949, as manager of drilling and production.

O. C. Ferguson, formerly district chief clerk, Imogene district, was promoted to assistant division chief clerk, Southwest Texas division, Humble Oil and Refining Company. He was succeeded at Imogene by **E. M. Bedford,** formerly district chief clerk at the Sugar Valley district, Gulf Coast division.

J. C. Arvin, district chief clerk, Stratton district, moved to the Willamar district and **Eddie Mahan,** district chief clerk at Willamar transferred to Stratton.

T. N. Barber, district chief clerk of the Galveston bay district was transferred to the Sugar Valley district as district chief clerk.

John H. Pittman, district civil engineer, Anahuac district, Gulf Coast division, was transferred to the gas construction division, Houston, as senior civil engineer.

R. A. Watson, supervising petroleum engineer, Gulf Coast division office transferred to the petroleum engineering division, Houston office, as supervising petroleum engineer.

H. M. Lemex, supervising petroleum engineer, drilling equipment division, Houston office, transferred to the Gulf Coast division office as supervising petroleum engineer.

T. V. Miller, supervising petroleum engineer, petroleum engineering division, Houston office, was transferred to the Gulf Coast division office as supervising petroleum engineer.

J. J. Bardgette, civil engineer, Southwest Texas division office, transferred to the Anahauc district as district civil engineer.

Harold B. Renfro has announced the establishment of his office in Dallas as a petroleum consultant at 4225 Greenbrier.

Renfro was graduated from the University of Tulsa with a BS degree in 1939. He then attended the University of Wisconsin from 1939 to 1942, receiving both the MS and PhD degrees in geology there.

After serving in the U. S. Navy from 1942 to 1946, Renfro joined the faculty of the University of Tulsa as Professor of Geology. In 1948 he affiliated with Stoddard Oil Company of Dallas as engineer and geologist, and continued there until establishing his own office.

Hubert E. Menger has been named vice president and manager of exploration for Monterey Exploration Company of San Antonio, Texas. He studied petroleum engineering at Texas A. & M., and was graduated from Texas University in 1936 with a BS in geology. During his college years, he worked for Shell Oil Company, but upon graduation joined Stanolind Oil and Gas Company as a geological scout.

Also announced is the appointment of **Howard E. Davis** as district geologist for Monterey Exploration Company in Midland, Texas. Davis was graduated from University of Texas. Since his graduation and until this present oppointment, he had been with Honolulu Oil Corporation, most recently as district geologist in Midland.

Ray E. Carter has been named head of the Triangle Oil Company with headquarters in Tulsa, Oklahoma. The new firm will specialize in oil and gas production and development.

Carter was formerly chairman of the board of Unit Rig and Equipment Company, with which he had been associated for 16 years. **E. A. Smith,** president of Service Drilling Company, and **William Guir,** one of the founders of Unit Rig and Equipment Company, and its president until his retirement two years ago will be associated with Carter.

Carter is a graduate of the University of Kansas, and is responsible for a large part of the designing and development of the line of equipment manufactured by Unit Rig and Equipment.

J. J. Frommer

W. B. Berwald

G. B. Gariepy

R. G. Kurtz

J. J. Frommer, manager of The Ohio Oil Company's Shreveport, Louisiana, production division since 1944, has retired, closing 34 years of service with the company.

W. B. Berwald, assistant Shreveport division manager, has been appointed to succeed Frommer as manager of the division.

Glen B. Gariepy, Los Angeles division geologist, will become assistant Shreveport division manager on September 1.

R. G. Kurtz, senior geologist at San Antonio, Texas, has been named Los Angeles division geologist succeeding Gariepy.

With his retirement from Ohio Oil, Frommer also leaves the chairmanship of the Haynesville operators committee and the Cotton Valley Operators Committee in Louisiana.

Frommer began his permanent association with The Ohio Oil Company as foreman at Ranger, Texas, in 1919. He was appointed division manager in 1944.

Berwald attended Carnegie Institute of Technology, and received his degree in petroleum engineering at the University of Pittsburgh. He has served as assistant division manager at Shreveport since September, 1952.

Gariepy is a graduate of the University of Wyoming and did graduate work at the University of Wisconsin and Stanford University before joining Ohio Oil as a field geologist in the Casper, Wyoming, division in 1926.

A graduate of the University of Utah, Kurtz was employed by Ohio Oil in 1927 as a geologist in the Rocky Mountain region. Four years later he was assigned to the staff of the chief geologist in Findlay, Ohio, where he served until his transfer to San Antonio in 1948.

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2. The McCullough Magna-Tector located the stuck point in 7" O.D. drill collars at 8100 feet. The String Shot loosened the first joint above the stuck point. All free pipe was recovered successfully even though operations were conducted in a dog leg in a 56° slant hole.

3. The McCullough Magna-Tector was run through 2⅞" tubing, through the 2" I.D. of a spear and located the stuck point in 6⅝" liner at 5185 feet. All free pipe and the stuck portion of the liner, were recovered in a few simple, economical operations.

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XUM

Running Tour

Howard Kiatta has been promoted to division land and leaseman of Rocky Mountain division, producing department of The Texas Company, and transferred to Denver, Colorado.

T. O. Winn, assistant division land and leaseman, Louisiana division, will replace Kiatta as landman on the general manager's staff and will be transferred from New Orleans to Houston, effective the same date.

Kiatta was graduated from business college and holds a law degree. He joined Texaco in February 1918. He was moved to the staff of the general manager, producing department, his present position, last year.

Winn was employed by The Texas Company in 1923. He was promoted to his present job as assistant division land and leaseman, Louisiana division in 1944.

William B. Agocs, formerly head of the Department of Geophysics of the University of Tulsa, Oklahoma, has joined the staff of Aero Service Corporation, Philadelphia. Dr. Agocs will be available as a consultant on airborne magnetometer surveys and other geophysical survey problems.

From 1937 to 1940 Dr. Agocs was geophysicist in charge of refraction and reflection seismic exploration for Gulf Research and Development Company, in Venezuela, Kuwait, England, and Denmark. From 1940 to 1944 he entered the teaching field in physics and geophysics at Lehigh University, and was active as a consultant for oil and mining companies.

For the past three years, Dr. Agocs has been associated with the University of Tulsa, in addition to serving as a consultant on airborne magnetometer surveys and ground magnetic studies for mining and oil companies.

Nick Van Wingen, well known Pacific Coast petroleum engineer, and vice president of Petroleum Technologists, Inc., Montebello, announces his resignation from that position to engage in private practice as a consultant, with offices at 903 Fair Oaks, South Pasadena. He will, however, retain his place on the P. T. board of directors.

Van Wingen is a graduate of California Institute of Technology and of University of California. He was formerly chief evaluation engineer for Richfield Oil Corporation, and has had wide experience in the diverse phases of oilwell drilling and production over the past 20 years.

He leaves almost immediately for Turkey where he will make an engineering evaluation of its two oil fields for the Turkish government. He expects to return about the middle of September.

W. H. Justice

R. F. Carlson

E. B. Roudebush

William H. Justice, formerly technical advisor for La Gloria Corporation in Corpus Christi, Texas, was promoted to the position of drilling and production manager of La Gloria. He succeeds Paul R. Turnbull in that position.

Justice was graduated from the University of Oklahoma in 1935 in chemical engineering. He joined Tidewater Associated Oil Company then, going with La Gloria in 1948.

Roy F. Carlson has joined the staff of the Division of Production of the American Petroleum Institute in Dallas as assistant to the director. He will be in charge of the Division's drilling and production practice programs, and district activities.

Carlson has been a member of the editorial staff of the Oil and Gas Journal since 1948. His most recent assignment has been West Texas editor for the Journal. Prior to his affiliation with the trade publication, Carlson was employed by Phillips Petroleum Company.

Carlson was educated at the Colorado School of Mines and Tufts College, obtaining a petroleum engineering degree at the former, and a mechanical engineering degree at the latter.

The appointment of the new assistant to the director rounds out the changes in the Division of Production staff resulting from the retirement of C. A. Young as director. William H. Strang succeeded Young as director in July.

Everett B. Roudebush has joined Northern Natural Gas Producing Company as manager of land and leasing. A veteran of 17 years experience in the petroleum industry, Roudebush has been with Gulf Oil Company for the past 15 years. At the time he joined Northern he was assistant manager and acting land man for Gulf in its Billings, Montana division. Since October, 1950, he has been assigned to Gulf's executive training program.

Roudebush attended Oklahoma A & M and also studied at the University of Tulsa and Oklahoma City University. His offices will be in Omaha.

Dr. John H. Buck has joined Well Surveys, Inc., Tulsa, as technical director. Dr. Buck received his PhD in physics in 1938 at the University of Rochester. He was an instructor in physics at Massachusetts Institute of Technology for three years assisting also in design, construction, and use of the MIT cyclotron in research on proton induced radioactivities. Dr. Buck was head of the physics division of Socony-Vacuum Oil Company's Paulsboro Laboratory in New Jersey for four years and was thereafter engaged by the U. S. Atomic Energy Commission at Oak Ridge, Tennessee.

J. S. Welboan, Jr., is being promoted to assistant division manager by The Texas Company, and will continue to be in the geophysical division Houston office. Welboan was graduated from the University of Oklahoma in 1935, and entered the employ of The Texas Company in 1936.

V. E. Child is being promoted to assistant to division manager and will continue to be located in the Houston office. Child was graduated from the University of California in 1936 and has been in geophysical work since that time.

T. L. Kunkel, supervisor of geophysical operations in the West Texas division, with headquarters in Fort Worth, is being promoted to assistant to division manager and transferred to the Houston office of the geophysical division. Kunkel was graduated from Texas A. & M. College. He entered the employ of The Texas Company in 1934.

Fred W. Bush, formerly manager of lands, Pacific Coast area, has been appointed manager of exploration, Williston Basin division, Union Oil Company. His headquarters will be at Bismarck, North Dakota.

Howard Said will succeed Bush as manager of lands, Pacific Coast area. He previously was assistant manager of lands, Pacific Coast area.

K. C. M. Anderson becomes administrative assistant for the field department, a newly created position. He formerly was assistant to manager of field operations, Pacific Coast.

B. B. Brison, formerly in Union's field office in Santa Paula, will join the head office group as assistant manager of field operations, Pacific Coast.

W. E. "Bill" Morgan continues as acting manager of operations, Rocky Mountain division, with headquarters at Denver.

Wade W. Turnbull, Mattoon, Illinois, has been named exploration manager for The Carter Oil Company's eastern division and **J. E. Lewark,** Mattoon, has been made division geologist.

Turnbull received his geological degree in 1939 from the University of Nebraska and began work for Carter immediately.

Lewark received his masters degree in geology from the University of Illinois, and began work for Carter in 1940 following graduation.

Running Tour

J. B. Hamilton has been named superintendent of production for Sun Oil Company's Rocky Mountain production division, Denver. Hamilton had been district superintendent of production for the West Texas district in the Southwest division since 1947.

Other Southwest production division changes announced are:

Cecil A. Colville, Midland, Texas, from assistant superintendent, West Texas district, to district superintendent succeeding Hamilton.

E. Lloyd Kownslar, field superintendent, Colorado City, Texas, to assistant district superintendent, replacing Colville.

Nelson J. Sapp, Jr., foreman, Garcia Area, McAllen district, southwest Texas, to Colorado City replacing Kownslar. Colorado City is now an area office instead of a sub-district office.

C. C. Bengston, production superintendent, Calgary, Alberta, Canada, to assistant field superintendent, with headquarters in Midland, Texas.

R. K. Beggs, foreman, Robert Lee area, West Texas district, to the Gainesville area, East Texas district. He succeeds P. S. Dudley, who retired July 1 as assistant field superintendent in charge of the Gainesville area.

Hamilton, new production head for the Rocky Mountain division, joined Sun in 1930 as a roustabout at Brenham, Texas. He became field superintendent at Delhi, Louisiana, in 1946.

Colville joined Sun as a roustabout at Henderson, Texas, in 1936 after graduating from Southern Methodist University. He was made assistant district superintendent at Midland October 16, 1951.

Lee T. Meador has been named assistant traffic manager of Sun Oil's Southwest production division. He had been first assistant in the Dallas office traffic department.

He succeeds **E. N. Earle** of Dallas who retired July 1 after 28 years with the company.

Since joining Sun in 1941, Meador worked in the Dallas office traffic department, except for a year during World War II when he was in New Orleans.

J. M. Wanenmacher of Keplinger and Wanenmacher, consulting petroleum engineers, Tulsa, Oklahoma, has gone to Colombia, South America, to visit the De Mares Concession of Empresa Colombiana de Petroleos, which is in the Magdalena Valley. He will be gone approximately one month. Keplinger and Wanenmacher are engineering and geological consultants to the Empresa. The concession produces approximately 35,000 bbl of oil daily and covers 1,250,000 acres.

Frank A. Boyd has been appointed petroleum engineer in charge of Texas Eastern Transmission Corporation's Pittsburgh, Pennsylvania, office. Boyd was previously a consulting geologist and engineer in Pittsburgh, and prior to that was chief geologist for Manufacturers Light and Heat Company.

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DW 1

Running Tour

W. M. Paggi has been named to the newly created position of assistant superintendent of Sun Oil Company's Houston district.

Paggi, former field superintendent of the North Markham-Bay City area, will retain his office in that area.

The Houston district includes all operating areas in the Gulf Coast division west of the Trinity River in Texas. **J. O. McPherson** is district superintendent.

V. T. Evans, petroleum engineer at North Markham, succeeds Paggi as field superintendent for the North Markham-Bay City area.

Paggi, a petroleum engineering graduate of Texas A. & M., has been field superintendent at North Markham since April, 1946.

Evans, a Texas University graduate in petroleum engineering, has worked in numerous fields in the Gulf Coast division since joining Sun in 1938.

J. L. Stephens, Conservation Committee of California Oil Producers representative from District No. 9, was elected chairman of the Administrative Committee. Stephens is assistant to the executive vice president of Chanslor-Canfield Midway Oil Company. Other members of this committee are **T. W. Bell, Chester F. Dolley, W. L. Hobro,** and **T. H. Sherman.**

An engineering board was also elected. **F. T. Lloyd,** representative from District No. 30, and chief valuation engineer for Richfield Oil Corporation, was elected chairman. Other members elected were **George August, R. C. Gentry, H. K. Grant, James G. Heid, Joseph Jensen, D. G. Kingman, Holmes Miller, W. M. Moody,** and **J. O. Richardson.**

Claude E. Leach has been appointed manager of the geological department, Mid-Continent division of Tide Water Associated Oil Company.

Leach will have headquarters in Houston and be responsible for all geological work in Tide Water's Mid-Continent division. He is a member of the exploratory committee which consists of: **Noel W. Boston,** chairman; **Tom G. Kelliher,** manager land department; **Claude E. Leach,** manager geological department, and **Ed S. Sherar,** manager geophysical department.

Coxey Evans has been transferred from Cities Service Oil Company's Michigan-Illinois division to Oil Hill as assistant division superintendent for East Kansas to fill the vacancy left by **J. P. Murray's** recent retirement from the company.

R. C. Cooper of Great Bend is being transferred to Olney, Illinois, as assistant division superintendent of production in the Michigan-Illinois division. **J. C. McClure** of Great Bend, formerly assistant to Cooper, has been named assistant division superintendent of production for the West Kansas division.

O. C. Atkinson of Great Bend has been named division engineer for West Kansas.

Evans joined Cities Service as a junior engineer after graduating from Texas A. & M. He was appointed assistant division superintendent for Michigan-Illinois in 1944. After graduating from Washington State College Cooper joined the company as a junior engineer in 1927. He was named assistant division superintendent in 1948.

McClure was first employed by Cities Service in 1937 after graduating from Oklahoma University. He was named assistant to Cooper in 1949. Atkinson joined Cities Service in 1936 after graduating from Oklahoma A. & M. He was appointed assistant division engineer at Great Bend earlier this year.

R. F. Darrow, Griffin, Indiana, district production superintendent for Continental Oil Company, has been promoted to production superintendent of the Kansas division, with headquarters in Wichita. He succeeds T. C. Davis, who has resigned from the company.

It was announced at the same time that **C. M. Tarr,** also of Griffin, district petroleum engineer, has been promoted to district production superintendent, succeeding Darrow.

Darrow joined Conoco in 1933. He was named Conoco's district production superintendent at Griffin, Indiana, in 1951.

Tarr majored in petroleum engineering at Colorado School of Mines. He joined Conoco in 1938.

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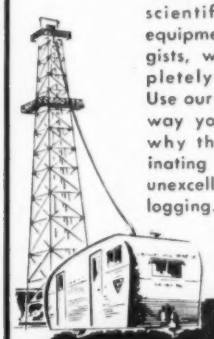

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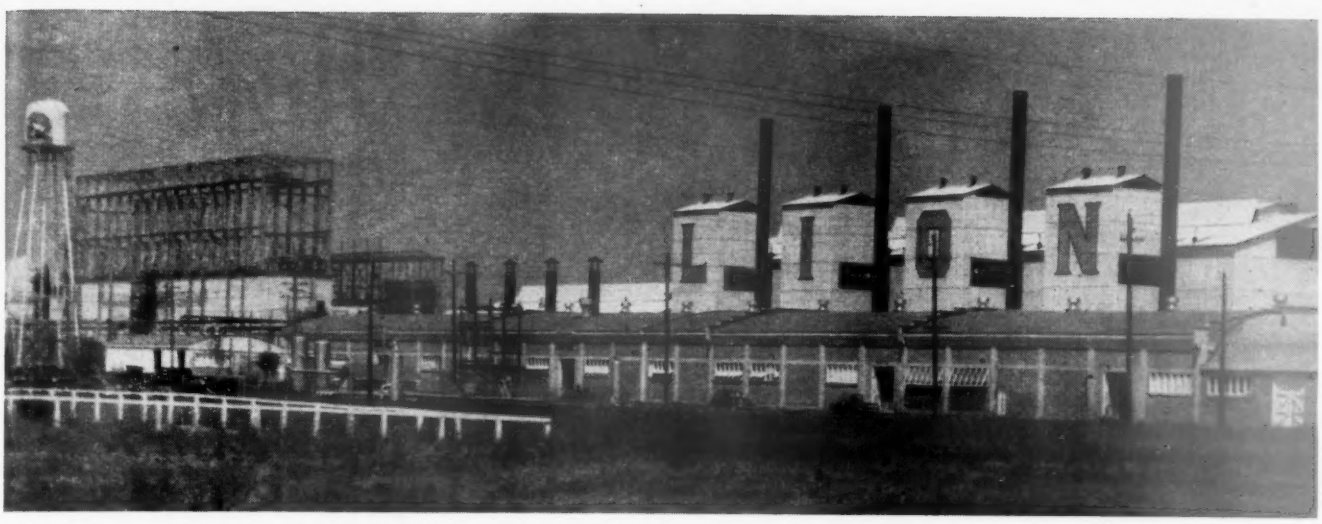


LION'S ammonia plant showing (left to right) administration building and water tank, reform and synthesis structures in background.

Synthesis of Petrochemicals—2

Ammonia from Natural or Refinery Gases and Air

Hydrogen from light hydrocarbons, nitrogen from the air combine chemically to form one primary industrial chemical, via catalysis

ARCH L. FOSTER*

It is a literal truth nowadays that much of the natural gas being withdrawn from the earth is being returned thereto for the direct advantage of the human race. Yet the form in which it is returned is so widely separated, chemically and physically from the original gas that the connection between raw material and product is obvious only to the initiated.

The synthesis of ammonia requires large quantities of cheap hydrogen and this hydrogen is obtained direct from natural or refinery gases via a catalytic process. The all-important nitrogen is obtained from the air. To "fix" the gaseous ammonia, NH_3, in solid form to facilitate handling, some of the product ammonia may be oxidized to nitric acid, HNO_3, which is combined in metathetical reaction with more NH_3 to form NH_4NO_3, ammonium nitrate, a white, under certain conditions explosive, powder that may be pelleted or handled in powder form, usually the first. In this manner the reluctantly reactive atmospheric nitrogen, nearly 80 per cent of the air, is brought into reactive condition to produce one of the most vital of plant foods, as well as intermediate material for innumerable chemical syntheses.

Chemically the synthesis falls into two main reactions. The first is the dehydrogenation of methane, ethane, etc., with superheated steam,

$$CH_4 + 2H_2O = CO_2 + 4H_2 \quad . \quad (1)$$

The carbon dioxide, CO_2, has no further part in the synthesis and is discarded. In some instances it is solidified to form "dry ice," as is done at Spencer Chemical at Pittsburg, Kansas. The molecular hydrogen is combined with atmospheric nitrogen,

$$N_2 + 3H_2 = 2NH_3 \quad . \quad . \quad . \quad . \quad (2)$$

So expressed the synthesis is a simple operation in two steps. Commercial accomplishment is by no means so simple.

Commercial Synthesis Operations Involved

Although different plants produce ammonia under somewhat different process details, the commercial operation is carried out as given in the succeeding discussion, which shows the major steps and details. Raw gas from natural gas or refinery supply is purified, including removal of sulfur compounds by, for example, beds of zinc oxide, ZnO. In one of the earlier plants a series of five vessels, each containing nearly 25 tons of the oxide in ball or pellet form are employed, through which the raw gas passes. The oxide is placed on several trays with open spaces between, the number of trays being determined largely by the size of the vessels, the amount of oxide installed, the amount of sulfur in the gas and the space velocity desired for the gas in passing through the trays or "beds" of reactant.

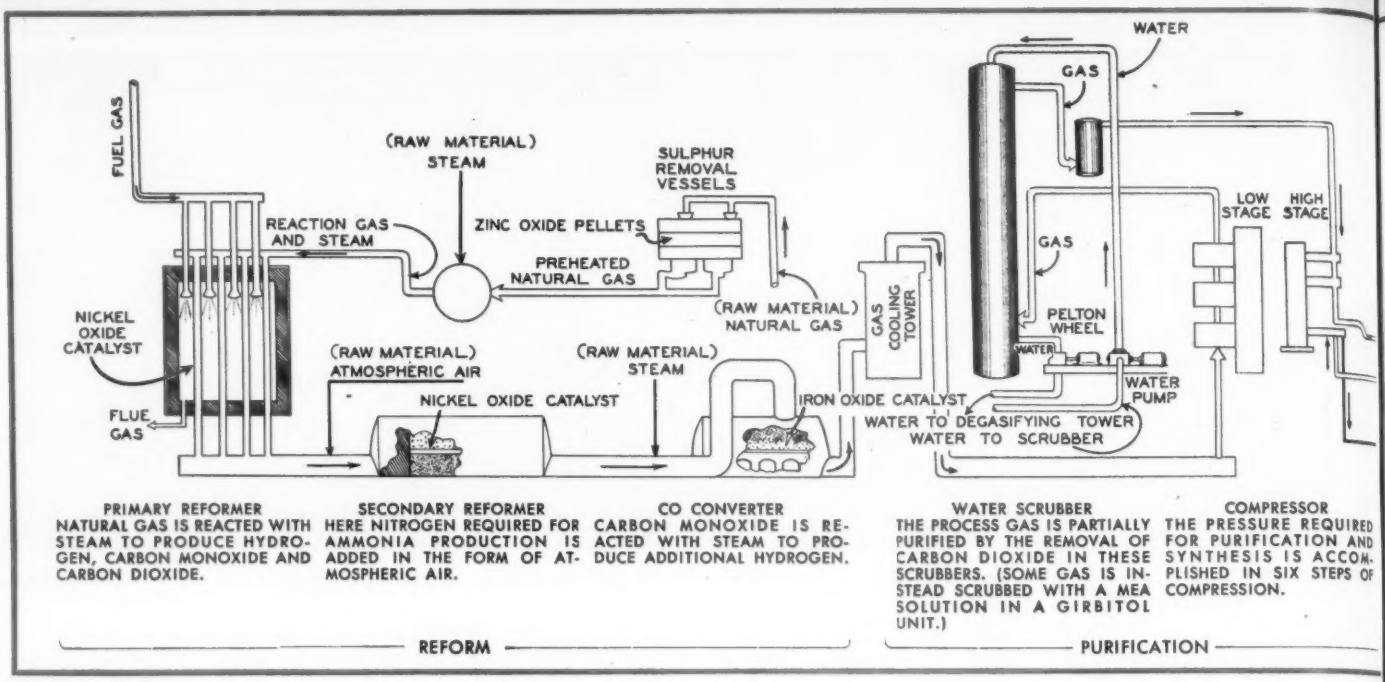
Even when operating on gases containing only a few parts per million of sulfur it is necessary to remove it quantitatively since sulfur is a strong "poison" for the catalysts used later in the system. Zinc sulfide is formed by the reaction. This sulfide and the analogous oxide may each be converted to the other, depending on the temperature of the reactants. At about 750 F as a practical plant temperature the absorption of sulfur by the zinc from the raw gas is quantitative, at mild pressures up to 100 psig or lower. The sulfur is replaced by oxygen to re-form the oxide, in the presence of air at temperatures above 1000 F. Whether or not regenerating equipment is provided in the design of an ammonia unit is determined by the ratio of gas treated to oxide installed, and of course primarily to the sulfur content of the raw gas.

"Clean" Gas Is Reformed

The desulfurized gas is sent to a mixing operation in which steam heated to 750 F is added to the stream of hydrocarbon—largely methane—and the mixture passes through the reformer tubes that are header-connected and contain pellets, cylinders or rods of an inert carrier such as silica, alumina, diatomaceous earth, etc., on which is deposited a thin film of nickel metal, the active de-

*Editor, Refining and Petrochemical.

EXCLUSIVE


FUEL GAS
(RAW MATERIAL) STEAM
SULPHUR REMOVAL VESSELS
REACTION GAS AND STEAM
ZINC OXIDE PELLETS
PREHEATED NATURAL GAS
(RAW MATERIAL) NATURAL GAS
NICKEL OXIDE CATALYST
(RAW MATERIAL) ATMOSPHERIC AIR
(RAW MATERIAL) STEAM
NICKEL OXIDE CATALYST
IRON OXIDE CATALYST
FLUE GAS
GAS COOLING TOWER
WATER
GAS
LOW STAGE
HIGH STAGE
GAS
PELTON WHEEL
WATER
WATER PUMP
WATER TO DEGASIFYING TOWER
WATER TO SCRUBBER
PRIMARY REFORMER
NATURAL GAS IS REACTED WITH STEAM TO PRODUCE HYDROGEN, CARBON MONOXIDE AND CARBON DIOXIDE.
SECONDARY REFORMER
HERE NITROGEN REQUIRED FOR AMMONIA PRODUCTION IS ADDED IN THE FORM OF ATMOSPHERIC AIR.
CO CONVERTER
CARBON MONOXIDE IS REACTED WITH STEAM TO PRODUCE ADDITIONAL HYDROGEN.
WATER SCRUBBER
THE PROCESS GAS IS PARTIALLY PURIFIED BY THE REMOVAL OF CARBON DIOXIDE IN THESE SCRUBBERS. (SOME GAS IS INSTEAD SCRUBBED WITH A MEA SOLUTION IN A GIRBITOL UNIT.)
COMPRESSOR
THE PRESSURE REQUIRED FOR PURIFICATION AND SYNTHESIS IS ACCOMPLISHED IN SIX STEPS OF COMPRESSION.
REFORM
PURIFICATION

FLOWCHART of Lion Oil's ammonia plant showing major steps in synthesis.

hydrogenation catalyst. Again, large amounts of catalyst are employed for long catalyst life; nickel is very reactive with, and is poisoned easily by sulfur, "killing" its catalytic activity quickly. A plant that produces between 400 and 500 tons of ammonia per day employs nearly 100,000 lb of this supported catalyst in four furnaces containing between 250 and 300 catalyst-reaction tubes. Incidentally, the reaction mixture contains three to four mols (reacting units) in steam (water) to one mol of gas. The theoretical amount of steam is twice the number of mols in the accompanying gas, methane, but an excess is used to tend further toward "pushing" the equilibrium in the direction of hydrogen production, the right side of Equation (1).

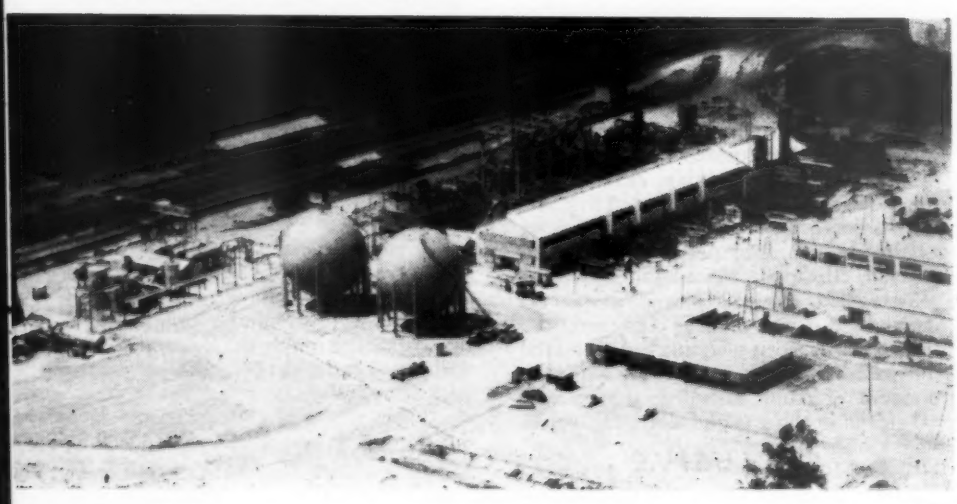
Reforming Temperature 1350 F

Temperatures in the reforming furnace tubes or reactor vessels of whatever design may vary from plant to plant but typical conditions are about 1350 F and a few pounds pressure above atmospheric. More than 90 per cent of the methane is converted to the dioxide and hydrogen in the first pass of an efficient unit and the reactions and resulting new molecule formation raises the total gas volume by nearly five times. The original gas volume is more than 20,000 cu ft per ton of ammonia made. Equilibrium in the direction of hydrogen formation is nearly theoretical, that is, practically all the reacting materials pass to the free hydrogen and carbon dioxide status.

As the reacted gases pass to the next or final reforming step, they are mixed with air for the double purpose of obtaining additional oxygen to convert any carbon monoxide to the dioxide, and to introduce atmospheric nitrogen for the main reaction step. Some of the newly formed hydrogen burns with this oxygen to form water as steam, which reacts with any carbon monoxide present, that may have been formed by incomplete combustion of the carbon in the first or primary reactor furnace. This carries the monoxide to the dioxide and regenerates the hydrogen to continue on to the next step in the process, that occurs also in the secondary reactor. To complete the conversion to hydrogen and carbon dioxide the temperature in this second step is raised to between 1600 and 1700 F. The catalyst must be "carried" on a more refractory, that is, higher melting base than diatomaceous earth for example, to withstand the higher temperature; as much or more catalyst is employed here as is used in the first step.

The hot reactant gases, now five times the volume of original charge gases may be employed in exchangers to preheat incoming gases, or to generate steam or to heat any stream desired, and after mixing with more steam pass into a "CO converter" for eliminating the last traces of carbon monoxide. It is necessary that essentially all carbon be present at the dioxide to make easier its removal in the next step, before the final reaction of hydrogen and nitrogen. This converter, for a 500-ton plant, is packed with catalyst in pellet or rod form, as the Fe_3O_4 oxide, and the reaction is carried out at around 1000 F. This step in a unit of the size mentioned may install a quarter of a million pounds of iron oxide.

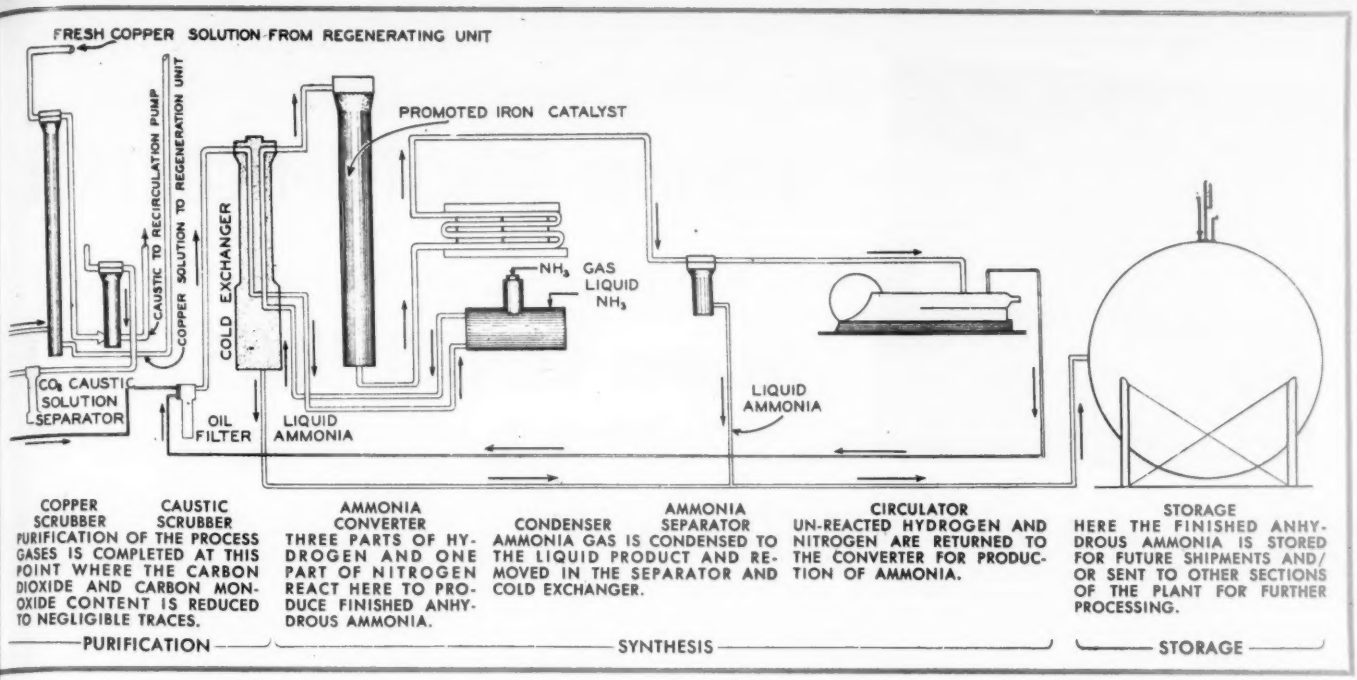
VICKSBURG works of Spencer Chemical Company is synthesizing ammonia for fertilizer and chemical intermediate.



Carbon Oxides Removed

The gases from this step contain nitrogen and hydrogen in approximately the theoretical proportions to form ammonia, that is, three mols of hydrogen to one of nitrogen. The total gas stream is cooled partially by exchange and then is washed in tall steel towers with water, passing upward countercurrent to water spray flowing downward over baffles, troughs, or other devices for breaking up the stream into thin sheets, droplets and so on for more intimate contact between water and gas.

As is typical in a refinery flow system, a surge tank, in this process a gas


FRESH COPPER SOLUTION FROM REGENERATING UNIT
CAUSTIC TO RECIRCULATION PUMP
COPPER SOLUTION TO REGENERATION UNIT
COLD EXCHANGER
PROMOTED IRON CATALYST
NH3 GAS
LIQUID NH3
CO2 CAUSTIC SOLUTION SEPARATOR
OIL FILTER
LIQUID AMMONIA
LIQUID AMMONIA
COPPER SCRUBBER
CAUSTIC SCRUBBER
PURIFICATION OF THE PROCESS GASES IS COMPLETED AT THIS POINT WHERE THE CARBON DIOXIDE AND CARBON MONOXIDE CONTENT IS REDUCED TO NEGLIGIBLE TRACES.
AMMONIA CONVERTER
THREE PARTS OF HYDROGEN AND ONE PART OF NITROGEN REACT HERE TO PRODUCE FINISHED ANHYDROUS AMMONIA.
CONDENSER
AMMONIA SEPARATOR
AMMONIA GAS IS CONDENSED TO THE LIQUID PRODUCT AND REMOVED IN THE SEPARATOR AND COLD EXCHANGER.
CIRCULATOR
UN-REACTED HYDROGEN AND NITROGEN ARE RETURNED TO THE CONVERTER FOR PRODUCTION OF AMMONIA.
STORAGE
HERE THE FINISHED ANHYDROUS AMMONIA IS STORED FOR FUTURE SHIPMENTS AND/OR SENT TO OTHER SECTIONS OF THE PLANT FOR FURTHER PROCESSING.
PURIFICATION
SYNTHESIS
STORAGE

holder of the conventional "city gas" variety or otherwise, is installed on the line to the compressors to smooth out the flow of synthesis gas to take care of production variations on the gas stream. The water wash has removed most of the CO_2 by solution. This water stream may be used to develop power or for other purposes, eventually being released in open towers where gas vents to the air.

Further compression may raise the synthesis gas pressure up to 1500-2000 psig, after which it is treated in "scrubbers" with a copper-ammonium compound or similar absorbent chemical that removes the carbon monoxide and dioxide quantitatively. Treating is carried out at essentially atmospheric temperature by passing the gas countercurrently in contact with the solution in for example a ring-packed tower. Finally the gas stream is washed with caustic solution of, say, five per cent NaOH to eliminate the last traces of carbon oxides, and final compression raises it to about 5000 psig for the final step in the synthesis.

Recycle gas is or may be mixed with the recompressed fresh feed gas and cooled as in water-surrounded coils and then by ammonia-expansion coolers (chillers) to temperatures of the order of 15 F, condensing and dropping out any NH_3 formed previously, as a by-product actually to the preliminary reaction steps.

"Promoted Iron" Synthesis Catalyst

A portion of the purified, cooled and recompressed mixed feed gas is vented just prior to entering the final reactor section to eliminate accumulations of inert gases such as excess nitrogen, methane, etc., that collect in the recycle gas mainly. The final synthesis step is somewhat involved, with various streams taken from the main gas stream for temperature control. The main stream is heated to about 800 F at the reactor entrance and the exothermic reaction of combining hydrogen and nitrogen to form ammonia, NH_3, then brings the reaction temperature up to about 1000 F while at the exit the reaction products are cooled to something like 300 F. All these conditions may vary widely in different plants, with catalysts of different activity levels, and the experience of the directing operators. The catalyst is referred to as "promoted iron catalyst."

Catalyst compositions data are guarded more or less, as employed in commercial installations. One "doubly promoted" catalyst reported in research results recently* shows: Ferric oxide, Fe_2O_3, 66.76 per cent; ferrous oxide, FeO, 28.7 per cent; alumina, Al_2O_3, (one promoter), 2.84 per cent; K_2O, potassium oxide, 1.04 per cent; and silica, SiO_2, 0.26 per cent.

Condensed ammonia formed in this section is liquefied and sent to rundown receivers. Unreacted gases go to recompression and recycle. The ammonia produced is determined by weight in the rundown tanks, for example.

Nitric Acid by NH_3 Oxidation

So far as ammonia synthesis is concerned the process is complete when the liquefied NH_3 is received in the tanks. The product then is ready for application in any number of syntheses and commercial manufacturing processes, ranging from refrigeration agent to urea plastics. For fertilizer use, for example, it is necessary to react ammonia with nitric acid, sulfuric or other permissible acid to "fix" the ordinarily gaseous ammonia, which must be cooled under pressure to become a liquid. Recently liquid ammonia has been released directly into irrigation water in which it dissolves, thus conveying it to vegetation without intermediate fixation with acidic components. Sulfuric acid combined with ammonia adds sulfur compounds to the soil; nitric acid adds more nitrogen and is used widely for this purpose. Ammonium nitrate, however, especially in its commercial form containing various impurities, can become explosive under the "right" conditions. Removal of these trace impurities is expensive, in some cases prohibitive, and this is done but seldom if ever, since they offer no problem in fertilizer.

*Experimental Reaction Rates in the Synthesis of Ammonia; R. M. Adams and E. W. Comings, Chem. Eng. Prog., 49, 359 (July, 1953).

Platinum-Rhodium Oxidation Catalyst

To make ammonium nitrate for fertilizer or any other purpose, a portion of the ammonia synthesized is burned in the presence of a platinum-rhodium gauze catalyst—or in other physical form if desired—with air to produce nitric oxide, NO, and water as a by-product. The liquid ammonia from storage may be vaporized by any convenient means as with heat exchange with oxide gas stream. At a temperature of 1600-1700 F, nitric oxide, NO, is oxidized further to nitrogen dioxide, NO_2, which latter is combined with water to form the acid. The entire series of reactions is represented by the combined equations,

$$4NH_3 + 5O_2 = 4NO + 6H_2O$$

$$4NO + 3O_2 + 2H_2O = 4HNO_3.$$ (Nitric Acid.

Merely bringing nitric acid and ammonia together completes the metathetical reaction giving a white powder which may be pelleted for handling in any convenient manner. Liquid ammonia is shipped in drums and in tank cars, under pressure, the least expensive way of handling it if ammonia alone is the desired material.

Details of manufacture may vary from plant to plant, of course, as new information is obtained by experience, but the foregoing illustrates the general routine and the range of conditions for the various steps in this synthesis, one of the most outstanding in the chemical industry. * * *

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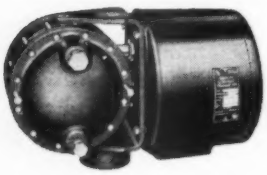

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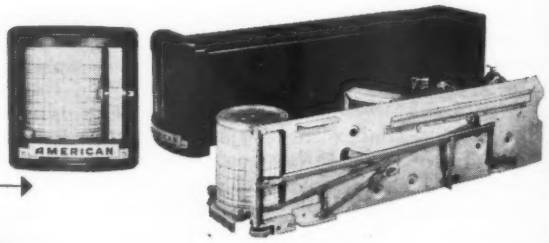
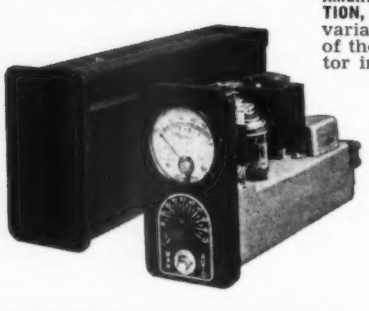


AMERICAN ELECTRONIC RECORDING CONTROL STATION, TYPE 162. Records the value of process variables and determines the control points of the controller. Type 161 provides indicator instead of recorder.



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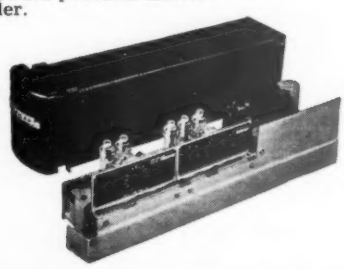
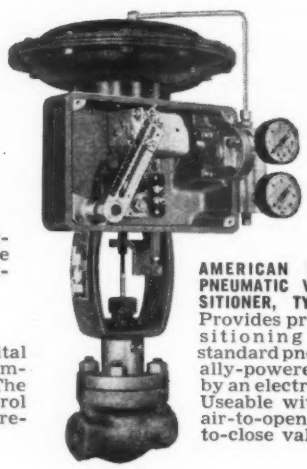


AMERICAN ELECTRONIC CONTROLLER, TYPE 163. Automatically controls the manipulation of a process variable by means of the Electro-Pneumatic Valve Positioner or an Electro-Pneumatic Transducer.



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Catalytic Polyforming of Gas Oil†

A combination of polyforming principle with cracking catalyst shows important improvements in yields and quality

L. Berg,* L. G. Mayfield,* H. A. Saner,* W. F. Polich,[1]
B. A. Ennenga,[2] R. B. Hamilton,[3] L. D. Lewallen,[4] R. L. Crecelius[5]

Thermal polyforming and catalytic cracking processes have been combined into one operation where a petroleum gas oil is catalytically cracked in the presence of added hydrocarbon gases. This process is called catalytic polyforming.

A series of experimental runs were carried out in pilot plant units holding 1000 ml of catalyst and capable of operating at pressures up to 2000 psig in a fixed bed system. The added gases investigated were propane, n-butane, isobutane, isobutylene, and a paraffin-olefin C_3-C_4 mixed gas. The catalysts tested included Cyclocel, Filtol, HF-activated alumina, synthetic bead, chrome-alumina, molybdenum-alumina, silica-magnesia, and Houdry synthetic aluminum silicate. The Houdry catalyst appeared to be the most effective.

Gasoline yields from the petroleum gas oil of 48 per cent per pass were obtained at 900-1200 psig at 435-465 C, 815-869 F, and a liquid hourly space velocity of 4.3 using a mixed paraffin-olefin gas mixture in a gas to oil weight ratio of 10. This compares with a maximum yield of 39 per cent gasoline per pass obtained by catalytic cracking in this unit. Octane number improvement by catalytic polyforming averaged 6-7 units higher than catalytic cracking.

THE polyform process as described by Offutt et al[3], is an efficient means for producing high quality motor gasoline by the thermal conversion of naphthas or gas oils at high temperatures and high pressures in the presence of recirculated hydrocarbon gases. These light hydrocarbons in the furnace make possible a substantially greater degree of severity of cracking by lowering the average molecular weight of the charge than it is possible to achieve in conventional thermal processes. These gases also minimize tar and coke formation by interaction with many of the olefins produced, some of which would otherwise undergo polymerization to form tar and coke. At the same time, the conditions of temperature and pressure are suitable for the conversion of C_3 and C_4 fractions into gasoline and increasing yields of gasoline are obtained at higher gas dilutions. The propane and butane fractions recycled within the process are in many cases supplemented with extraneous refinery gas streams for additional yields for gasolines.

Advantages of the polyform process can be readily seen in the attractive yields of motor gasoline which are obtained in naphtha polyforming, having octane numbers of 75-80 ASTM clear, and 84-93 Research, clear[5]. Furthermore, according to Offutt et al[4], gas oils are readily converted to gasoline by the polyform process. For example, a light paraffinic gas oil can be converted to gasoline with a yield of 60-70 per cent and an octane number of 73-76 ASTM in a single pass, or a light catalytic cycle stock can be converted to 50-60 per cent gasoline of 76-82 octane number.

The catalytic cracking process is an efficient and satisfactory means of producing high yields of high quality aviation and motor gasolines from gas oils. The generally higher yield and quality level of catalytically cracked motor gasoline over that of thermal cracking is the principal advantage of catalytic cracking. The gradually rising standard for automotive gasoline has forced the replacement of thermal cracking, which produced 65-70 octane gasoline, with catalytic cracking making 80 octane or higher. It has been noted[1] that this higher quality of catalytically cracked gasoline is due largely to the presence of isoparaffins and the absence of normal paraffins, as well as to its higher aromatic content.

To incorporate the advantages of the thermal polyforming and catalytic cracking processes, we have combined the two carrying out fixed bed catalytic cracking in the presence of added outside hydrocarbon gases and gas mixtures. This process we have called "catalytic polyforming."

To investigate such a process would involve the study of a large number of variables. Temperature, pressure, space velocity, nature of charge stock, outside gas composition, type of catalyst and gas to oil ratio are some of the major factors which would affect this process. These variables could give almost innumerable combinations. The purpose of this work was to investigate briefly the major variables to ascertain what advantages might be gained by catalytic polyforming. The outside gases studied were propane, n-butane, isobutane, isobutylene, and paraffin-olefin gas mixtures. Pressures up to 2000 psig were tried and mol ratios of gas to oil up to 15 were employed. A number of cracking catalysts were tested and space velocity was varied over a range of 0.5 to 5.

Although moving catalyst bed procedure is the accepted method of present day catalytic cracking, it was impractical in a preliminary investigation such as this to study catalytic polyforming on any basis other than fixed bed. For this reason the data on catalytic polyforming were obtained on a fixed bed technique and compared with fixed bed catalytic cracking.

Equipment

Two sets of equipment were constructed, one shown in Fig. 1 for pressures up to 1200 psig and the other, Fig. 2, for pressures up to 2000 psig. The reaction system shown in Fig. 1 was composed of four major sections: Feeding section, the reactor section, the condensing and receiving section, and the safety equipment.

The feeding section included a nitrogen cylinder, a feed cylinder made of 3-in. extra strong steel pipe with 3000 psig rated valves at each end, and a Jerguson visible liquid level gage. At the lower end of the Jerguson was attached a 6000 lb Vogt valve for adjustment of the rate of feed. From a side arm below the feed rate valve was attached a Black, Sivalls and Bryson frangible disk safety valve. The reactor

†This paper was presented at the American Chemical Society, Division of Petroleum Chemistry, Los Angeles, March, 1953, and has not appeared in any other publication.

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[4]Present address: Carter Oil Company, Billings, Montana.
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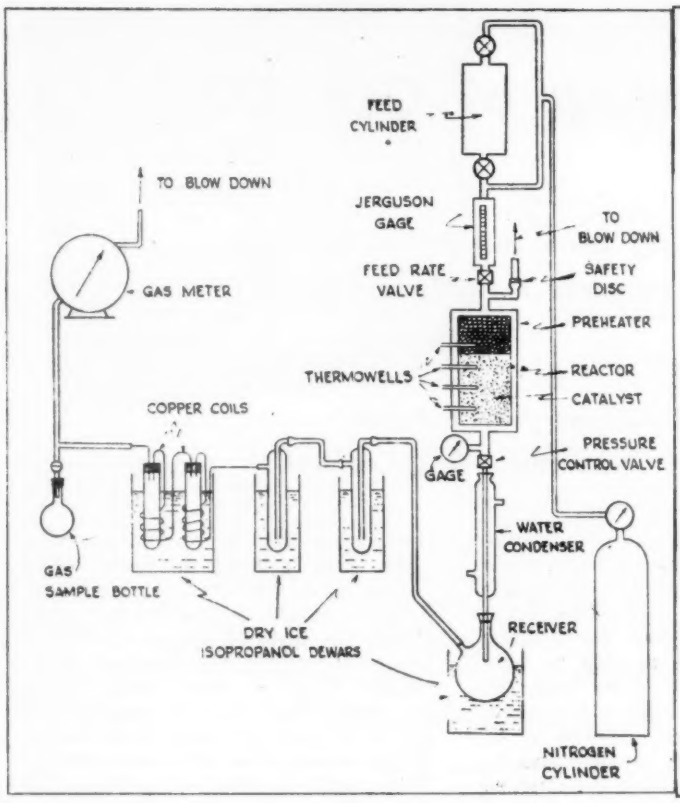


FIG. 1. Low pressure catalytic polyforming equipment.

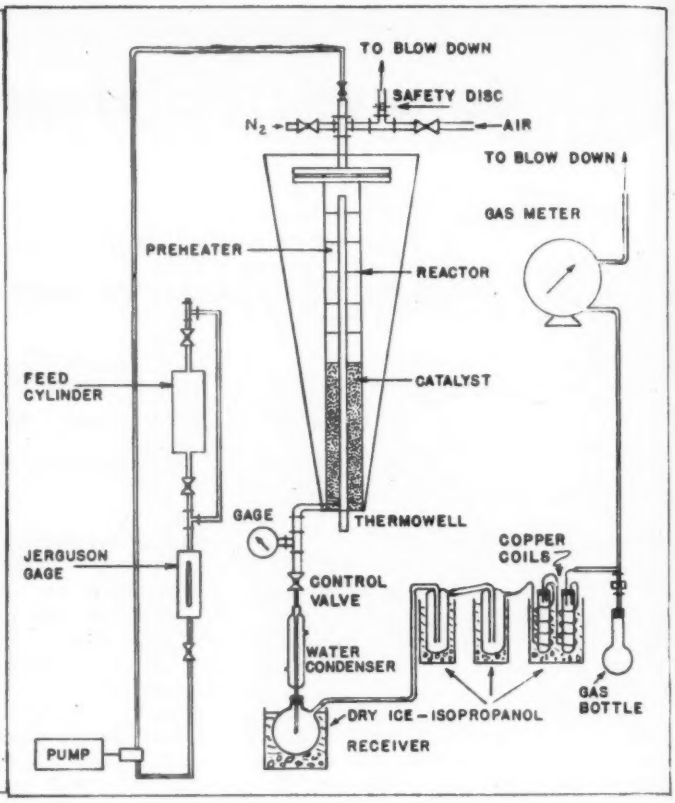


FIG. 2. High pressure catalytic polyforming equipment.

situated below the feed rate valve was made from a 15-in. section of 3-in. extra strong steel pipe. One thousand ml of catalyst of approximately ⅛-in. pellets were placed in the lower 11 in. of the reactor body and the remaining 4 in. were filled with assorted sizes of steel balls, the largest of which was 9/16 in. diameter, which served as the preheat section. A 0-2000 psig pressure gage and a 6000-lb one-half inch Vogt valve was connected below the reactor. This valve, operated manually, was employed to regulate the pressure in the reactor. Thermocouples were inserted in ⅛ in. steel pipe welded at approximately 3 in. intervals along the length of the reactor and served to indicate preheat and catalyst bed temperatures. Heating was accomplished and controlled by one 220-v and two 110-v Nichrome windings wrapped around the reactor.

The reactor effluent after pressure reduction was led through a glass Liebig condenser and the liquid product collected in the flask subsequently used in the distillation. Vapors not condensed in this flask passed through a series of four glass traps immersed in dry ice-isopropanol baths, through two copper coil condensers also immersed in dry ice-isopropanol and thence through a wet test gas meter and the blowdown line. A branch of this line was connected to an evacuated 200 ml round bottom, stopcock equipped flask used to take a gas sample for density determination.

Gasoline rectifications were carried out in a fifteen plate Oldershaw vacuum-jacketed column. Flue gas from carbon burn-offs was analyzed for CO_2, O_2 and CO in a standard Orsat apparatus. Analyses of gases from the feed cylinder after the run and of non-condensable gases issuing from the reactor during the run were made with a low-temperature (liquid nitrogen) gas fractionation apparatus. This unit was also used to make analyses on outside gases used in conjunction with the gas oil charge.

The unit depicted in Fig. 2 was used for the 1500 and 2000 psig runs. The feeding section consisted of the feed cylinder and Jerguson gage described above, connected to a Hills-McCanna plunger type pressure pump. The reactor was constructed from a three-foot section of 18-8-C, type 347, 2½ in. extra strong pipe. A vertical thermowell consisting of ¼-in. standard pipe extended through the reactor along its central axis. The bottom outlet was equipped with a 0-5000 psig pressure gage and a 25,000 lb stainless steel Aminco super pressure valve for manual pressure control. Frangible safety disk blowout and nitrogen and air lines were fitted to the top.

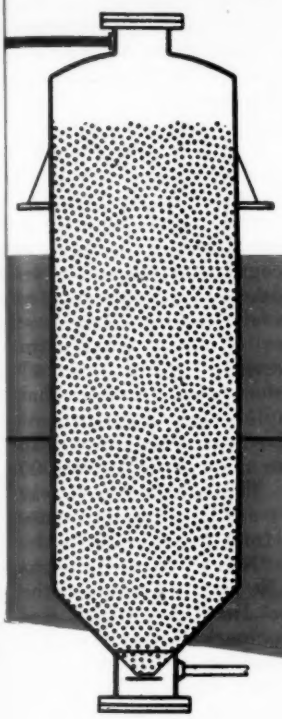
The reactor was originally designed to hold 3000 ml of catalyst because it was believed that liquid space velocities of 0.5-1.0 $hr.^{-1}$ would be optimum. Subsequent research with the 0-1200 psig unit shown in Fig. 1 indicated that the process operated efficiently at space velocities of 4-6 $hr.^{-1}$ Therefore the catalyst volume was reduced to 1000 ml by inserting a number of cylindrical steel blocks which were drilled to allow space for the thermowell and the feed. These blocks served effectively as a preheat section. Heat to the reactor was supplied and controlled by means of five 110-v Nichrome windings. The reactor was surrounded by a steel case and the space between reactor and case completely filled with diatomaceous earth to minimize heat losses. The condensing and rectification equipment was the same as described for the reactor in Fig. 1.

Methods

Prior to making a run, the feed cylinder was evacuated and filled with a weighed charge of gas oil. The feed cylinder was then placed in a refrigerator maintained at -40C where the cylinder and charge were cooled for a minimum of two hours but preferably overnight. When thoroughly chilled, the feed cylinder was placed on a 20 kilogram capacity balance and the desired quantity of gas added in the liquid state. After filling, the feed cylinder was allowed to come to room temperature and reweighed. The feed cylinder was placed in position above the Jerguson gage, nitrogen pressure in excess of reactor pressure applied and the Jerguson filled. By manually controlling the rate of liquid flow from the Jerguson to the reactor and intermittently refilling the Jerguson, the desired feed rate was accomplished.

Reactor pressure control during the runs was accomplished by manual control of the valve at the bottom of the reactor. No product was released from the reactor until the desired pressure had been reached and at the end of the run the reactor was quickly bled to atmospheric pressure by means of this valve.

A sample of noncondensable gas was collected near the middle of the run.



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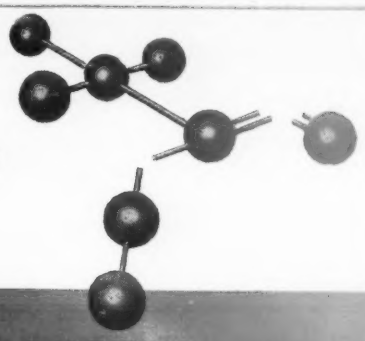

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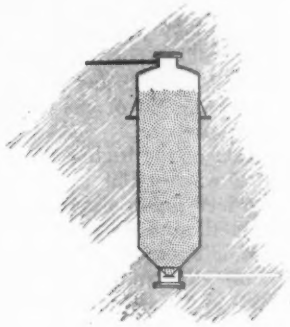

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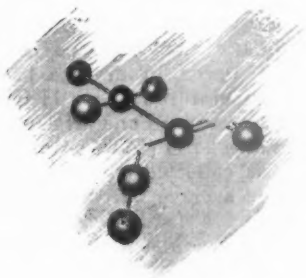

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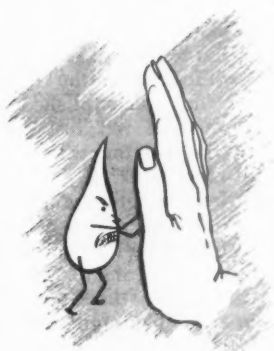

ATTAPULGUS MINERALS & CHEMICALS CORPORATION · **POROCEL** CORPORATION

Dept. Y, 210 West Washington Square, Philadelphia 5, Pa.

TABLE 1. Gas oil charge, inspection data.

ASTM Distillation — °F at	760 mm
Initial Boiling Point	527
10%	565
50%	622
90%	725
End Boiling Point	742
Gravity, A.P.I.	36
Viscosity, SSU/100F	53.6
Weight Per Cent Sulfur	0.31
Carbon Residue, %	0.02
Pour Point, °F	65

Small amounts of oil remaining in the reactor after completion of the run were removed by evacuating the reactor through a series of two cold traps. All liquid products were placed in the distillation flask and subjected to rectification in the Oldershaw column.

The loss of weight of feed gases which remained in the feed cylinder was determined as follows. At the end of the run the feed cylinder valves were closed and the cylinder removed from the system. The residual gases comprising nitrogen and the hydrocarbon were bled into a 34-liter tank. This allowed all the hydrocarbon to vaporize and be accounted for in the analysis of the low pressure gases in this tank. Analysis showed the residual hydrocarbon gas to be 10 grams. This correction of 10 gr of uncharged outside gas was subtracted from the weight of gas charged in each subsequent run.

The operation of the higher pressure unit of Fig. 2 was similar except that the use of the feed pump eliminated the manual feed method described above.

The receiving flask which contained the condensable gases in addition to the cracked stock was attached to the Oldershaw column. A dry ice - isopropanol mixture was used to cool the head in the first part of the distillation. The overhead product was collected in two vapor traps placed in dry ice baths. When the temperature reached 11 C, the receivers were changed and all material boiling between 11 C (52 F) and 210 C (410 F) was collected and considered gasoline. The average barometric pressure during these distillations was 640 mm Hg. but the above temperatures are corrected to 760 mm Hg.

The carbonaceous deposit laid down on the catalyst surface during operation had to be burned off to rejuvenate the catalyst and complete the weight balance. This was accomplished by passing air through a wet test meter and thence to the reactor which was maintained at 425 C (797 F.) The air rate was kept insufficient to allow the catalyst temperature to rise above 600 C (1112 F.) The progress of the burnoff could be followed by means of the thermocouples. At regular time intervals, usually 15 min at the beginning and end and 30 min during the major part of the burnoff, flue gas samples were withdrawn and analyzed for CO_2, CO and O_2 in the Orsat gas analysis apparatus. These per cents were plotted versus time and having the air feed rate, the area under this curve for CO_2 and CO was converted to carbon and the deposit calculated. A typical burnoff required five hours and 425 liters of air and produced 68 liters of CO_2 and CO which converts to about 28 grams of carbon at a barometric pressure of 640 mm Hg.

The octane ratings reported in Table 2 were determined by the Phillips Petroleum Company at its Bartlesville, Oklahoma laboratories.

Materials

The charge stock was from a mixture of paraffinic Texas Panhandle crudes obtained from Phillips Petroleum Company and having properties as listed in Table 1.

The hydrocarbon gases and gas mixtures were obtained from the Matheson Company, Inc.

Definitions

Several of the terms used in Tables 2, 4, 5, 6, 7, and 8 require definition as follows: Space velocity used here is volume of oil and outside gas in liquid state at 25 C, 77 F, per volume of catalyst (always 1000 ml) per hour. Conversion is the fraction of the oil charged which is converted to something other than oil, such as permanent gas, condensable gas, gasoline, or carbon. All the material boiling above the product gasoline except the carbon desposit on the catalyst is assumed to be unchanged gas oil. Recycle yield is a calculated value based on the assumption that the "unconverted" gas oil would give the same percentage of gasoline on recycling. Since it would undoubtedly give less, the recycle yield values given in the tables are probably too high. It is generally recognized that the first run or two on a fresh catalyst does not give reproducible results and therefore these first runs were discarded. The term "Number of Previous Runs on Catalyst" in the tables refers to the history of that particular sample of catalyst. The several tests involved passing from 250 to 500 gr of oil or mixture over the 1000 ml of catalyst. The same catalyst was used repeatedly and the amount of use can be gaged from the column in the tables headed "No. of Previous Runs on Catalyst". No deterioration of the activity of the Houdry catalyst was noted. Many comparisons are available in the several tables, one of the best being runs 44 and 45 in Table 8. Although the catalyst in run 45 had been

TABLE 2. Effect of catalysts in the catalytic polyforming of gas oil with n-butane.

Run number	1	2	3	4	5	6	7	8
Type of catalyst	Cyclocel	Filtrol	HF act. Alumina	Syn. Bead	Chrome-Alumina	Moly-Alumina	Silica-Magn.	Houdry
No. of previous runs on catalyst	8	5	4	6	3	5	5	4
Average reactor temp., °C	497	530	495	499	458	487	444	478
Average operating pressure, psig	900	900	900	900	900	900	900	900
Liquid space velocity, hr^{-1}	4.84	5.21	4.98	5.5	6.3	5.07	4.73	4.67
Mol ratio	2.79	2.66	2.61	2.97	3.37	2.75	3.19	2.78
Material charged								
Outside gas, type	n-Butane	n-Butane	n-Butane	n-Butane	n-Butane	n-Butane	n-Butane	n-Butane
Outside gas, gm	165	159	157	176	196	158	187	167
Charge stock, gm	255	258	259	255	251	248	253	259
Total charge, gm	420	417	416	431	447	406	440	426
Recovered material								
Hydrocarbon liquid prod., gm	197.8	151.4	208.4	173.4	204.5	141.6	197.4	156.5
Condensable gases, gm	169.3	189.3	176.3	193.4	207.6	149.9	204.7	209.5
Permanent gases, gm	33.2	48.0	22.3	40.8	23.2	49.2	18.8	35.0
Oil from catalyst, gm	3.1	1.2	2.3	1.5	1.7	2.4	3.7	0.2
Carbon by burn-off, gm	16.5	17.1	10.3	20.2	13.4	54.0	21.7	21.7
Total recovered, gm	419.9	407.0	419.6	429.3	450.4	407.1	446.3	422.9
Losses by difference, gm	0.1	10.0	3.6	1.7	3.4	1.1	6.3	3.1
Per cent losses on charge	0.02	2.39	0.87	0.39	0.76	0.27	1.43	0.7
Distillation data								
Gasoline, 7-204°C, gm	44.5	62.0	63.1	80.1	54.3	60.5	79.9	92.3
Residue, gm	123.5	109.5	150.1	80.4	154.2	85.0	105.7	80.2
Condensable gases, gm	132.2	134.9	151.0	167.3	169.4	119.0	181.0	163.7
Wt. per cent gasoline, 7-204 C	17.45	24.0	24.4	31.4	21.6	24.4	31.6	35.7
Wt. per cent conversion of oil charged	50.4	57.1	41.2	67.9	38.0	64.8	56.8	69.0
Wt. per cent ultimate yield, gasoline	34.6	42.0	59.4	46.3	56.8	37.6	55.6	51.7
Wt. per cent carbon laydown of oil chgd.	6.5	6.6	4.0	7.9	5.3	21.8	8.6	8.4
Volume per cent gasoline	19.9	27.4	27.8	36.8	24.6	27.8	36.0	40.7
Volume per cent conversion of oil chgd.	57.5	65.0	46.9	77.3	43.3	73.8	64.7	78.6
Volume per cent ultimate yield	39.4	47.8	67.7	52.8	64.7	42.8	63.3	58.8

TABLE 3. Octane ratings of catalytic polyformed gasolines.

Detn. No.	Catalyst	Outside gas	Pressure psig	Average reaction temp., °C	Average space velocity	ASTM octane number	Research octane number
1	Houdry	None	0	425	0.7	72.8	79.3
2	Cyclocel	n-Butane	900	485	5	66.6	72.8
3	Filtrol	n-Butane	900	500	5	73.6	79.7
4	HF Activated Alumina	n-Butane	900	475	5	69.8	74.1
5	Synthetic Bead	n-Butane	900	480	5	73.4	79.0
6	Chrome-Alumina	n-Butane	900	475	6	39.8	25.8
7	Molybdenum-Alumina	n-Butane	900	485	5	60.7	68.0
8	Silica-Magnesia	n-Butane	900	460	4.8	74.8	78.7
9	Houdry	n-Butane	900	401	5	74.5	80.3
10	Houdry	n-Butane	900	460	4.7	79.7	85.4
11	Houdry	n-Butane	900	480	5.2	79.0	86.6
12	Houdry	Propane	900	454	0.65	71.5	77.7
13	Houdry	Isobutylene	900	459	0.6	79.6	86.4
14	Houdry	Isobutylene	900	473	3.7	79.3	89.2
15	Houdry	Isobutylene	900	349	5.3	81.4	92.7
16	Houdry	Isobutane	0	460	5	56.4	64.0
17	Houdry	Isobutane	300	470	4.9	72.8	82.9
18	Houdry	Isobutane	600	485	5.1	71.7	80.9
19	Houdry	Isobutane	900	460	4.8	80.2	87.0
20	Houdry	Isobutane	1200	475	4.9	76.4	83.0
21	Houdry	Mixed Gas	0	460	4.7	81.3	93.8
22	Houdry	Mixed Gas	900	470	5	79.4	86.1
23	Houdry	Mixed Gas	1500	460	4.5	79.1	84.4
24	Houdry	Mixed Gas	2000	460	4.6	80.1	84.6

used four times as long as in run 44, the product yields are comparable, their small difference being attributed to the changes in space velocity and mol ratio.

Discussion of Results

Some of the principal variables in catalytic polyforming are type of catalyst, nature of outside gas, composition of oil treated, reaction temperature, operating pressure, space velocity, and ratio of gas to oil. The almost infinite number of combinations of these variables lead to a project which could be extremely extensive. In this laboratory, approximately 200 runs were carried out and even these yielded far more data than space permits in this paper. Copies of the theses containing the complete data are available from the authors. The data tabulated in this paper have been abstracted from the original theses and represent typical runs to demonstrate the several effects noted.

A series of runs were carried out with several cracking catalysts in order to find the one most suited to catalytic polyforming. Several variables were fixed. The outside gas employed with the gas oil was n-butane in a mol ratio of 2.5 — 3.5 and the operating pressure was maintained at 900 psig. The reaction temperature was varied until the maximum amount of gasoline was obtained. These are the runs tabulated in Table 2. In Table 3 the octane ratings of the product gasolines are presented. As the octane ratings were determined on a blend of gasolines from several runs on a given catalyst, the values of temperature and space velocity do not always agree exactly with those given for a specific run in one of the tables of operating conditions.

For comparative purposes, a series of runs was made with the synthetic Houdry catalyst in a conventional fixed bed cracking operation. The optimum conditions found are listed as Run 9 in Table 4 which gave 38.8 per cent gasoline at 52.6 per cent conversion. The octane ratings of the gasolines so produced by a number of runs are presented as Determination No. 1 in Table 3 and are 72.8 ASTM, clear and 79.3 Research, clear. Thus these data permit a general evaluation of catalytic polyforming compared with conventional catalytic cracking.

Cyclocel gave a maximum of 18 per cent gasoline at 50 per cent conversion and this yield was more or less constant over a wide range of conversion. The octane rating of the gasoline produced compared unfavorably with that produced by conventional catalytic cracking. Cyclocel is not considered an attractive catalyst for catalytic polyforming.

Filtrol was investigated at temperatures from 443 C to 518 C. Maximum yield of gasoline of 24.5 per cent was found at 52.5 per cent conversion although gasoline yield was essentially constant at conversions from 40 to 60 per cent. As in the case of Cyclocel, permanent gas formation became excessive, 30 per cent or more at the highest conversions studied. Octane rating of the product was comparable to that obtained by conventional catalytic cracking.

A series of four runs employing temperatures of from 450 C to 506 C was made with the HF activated alumina catalyst[2]. Maximum gasoline production, 25 per cent, occurred at 41 per cent conversion. The catalyst was unique in giving low carbon laydown and low permanent gas formation but otherwise has little to recommend itself. The octane rating of the product failed to equal that of catalytically cracked gasoline.

Synthetic bead catalyst was second only to Houdry catalyst, of those studied with respect to gasoline production. Employing a temperature range of 417 C to 558 C (783 to 1036 F) giving conversions of 41 to 77 per cent, the maximum gasoline yield of 31 weight per cent was obtained at 68 per cent conversion. The amount of carbon laydown and permanent gas produced were 8 and 16 per cent respectively at the point of maximum gasoline production. The octane rating of the gasoline product about equaled that of catalytically cracked gasoline.

Four runs at temperatures from 390 C to 500 C (734 to 932 F) were made with a chrome-alumina catalyst. The gasoline yields were relatively poor, exceeding only those obtained with cyclocel catalyst. Maximum yield per pass of 22 per cent was obtained at 38 per cent conversion. The octane rating of the product gasoline obtained with this chrome-alumina was much the poorest obtained with any catalyst studied being only 40 ASTM, clear and 26 Research, clear.

A molybdenum-alumina catalyst was tested next and the results were com-

TABLE 4. Effect of various gases in catalytic polyforming.

Run number	9	10	11	12	13	14	15	16	17
Type of catalyst	Houdry	Houdry	Houdry	Houdry	Houdry	Houdry	Houdry	Houdry	Houdry
No. of previous runs on catalyst.	10	3	2	17	29	32	33	41	32
Average reactor temp., C	375	380	410	427	370	325	387	411	455
Average operating pressure	0	900	900	900	900	900	900	900	900
Liquid space velocity, hr $^{-1}$	0.68	0.54	0.84	0.68	5.35	7.6	6.2	5.0	5.03
Mol ratio — gas to oil	—	2.67	3.09	3.0	3.37	0.7	—	2.49	3.33
Material charged									
Outside gas, type	None	Propane	Propane	Isobutylene	Isobutylene	Isobutylene	Isobutylene	n-Butane	Mixed gas
Outside gas, gm	—	120	142	197	219	203	426	160	181
Charge stock, gm	297	255	261	293	290	303*	—	277	263
Total charge, gm	297	375	403	490	509	506	426	437	444
Recovered material									
Hydrocarbon liquid prod., gm.	243.7	251.6	253.5	275.6	294.9	196.3	167.2	262.6	164.9
Condensable gases, gm	3.8	56.7	76.0	114.5	156.9	275.2	187.9	148.5	208.0
Permanent gases, gm	1.0	6.0	50.0	28.1	14.0	20.0	33.0	8.1	35.0
Oil from catalyst, gm	36.4	8.7	8.0	9.5	15.5	5.1	1.9	6.0	1.0
Carbon by burn-off, gm	6.4	26.5	6.5	65.8	30.7	15.5	45.4	6.9	28.1
Total recovered, gm	291.3	349.5	394.0	493.5	512.0	512.1	435.4	432.1	437.0
Losses by difference, gm	5.7	25.5	9.0	—3.5	—3.0	—6.1	—9.4	4.9	7.0
Per cent losses on charge	1.92	6.8	2.2	—0.71	—0.61	—1.2	—2.2	1.1	1.58
Distillation data									
Gasoline, 52-410 F, gm	115.1	98.8	74.2	130.0	114.4	68.5	108.5	123.8	81.8
Residue, gm	104.5	92.8	99.3	65.5	187.7	123.9	10.2	127.3	115.0
Condensable gases, gm	—	—	—	—	—	—	—	—	147.5
Wt. per cent gasoline, 52-410 F	38.8	38.7	28.5	44.3	39.4	33.7	25.4	44.6	31.0
Wt. per cent conversion of oil chgd.	52.6	60.1	58.8	74.4	30.0	—	—	51.8	55.9
Wt. per cent ultimate yield, gasoline	73.7	64.5	48.5	59.7	131	—	—	86.1	55.5
Wt. per cent carbon laydown on oil charged	2.15	10.4	2.5	22.4	10.6	3.1	10.5	2.5	10.7
Volume per cent gasoline	44.2	44.1	32.5	50.5	44.9	38.4	29.0	50.8	35.3
Volume per cent conversion of oil charged	46.0	64.8	63.6	81.1	85.8	—	—	56.6	63.7
Volume per cent ultimate yield	109.6	77.8	58.2	70.8	59.7	—	—	102.4	63.2

TABLE 5. Effect of pressure in catalytic polyforming.

Run number	18	19	20	21	22	23	24	25	26
Type of catalyst	Houdry	Houdry	Houdry	Houdry	Houdry	Houdry	Houdry	Houdry	Houdry
No. of previous runs on catalyst.	47	8	14	17	19	7	6	30	17
Average reactor temp., C	429	444	510	456	471	425	455	460	426
Average operating pressure, psig.	0	0	0	300	600	900	900	1200	1500
Liquid space velocity, hr $^{-1}$	0.65	4.4	4.9	4.75	5.1	4.89	4.65	5.05	4.12
Mol ratio	—	—	2.79	2.83	2.97	2.68	2.77	2.65	2.34
Material charged									
Outside gas, type	None	None	Isobutane	Isobutane	Isobutane	Isobutane	Isobutane	Isobutane	Isobutane
Outside gas, gm	—	—	171.4	174.7	180	165	164	164	155
Charge stock, gm	250	263	265	266	261	265	255	267	320
Total charge, gm	250	263	436.4	440.7	441	430	419	431	475
Recovered material									
Hydrocarbon liquid prod., gm.	222.4	206.1	141.6	180.3	165.6	216.8	169.6	165.3	242.4
Condensable gases, gm	9.6	26.2	252.3	195.9	193.2	177.3	180.4	198.2	168.7
Permanent gases, gm	4.13	5.8	29.5	31.2	46.5	16.1	30.8	29.4	19.2
Oil from catalyst, gm	1.9	11.0	1.7	0.3	0.2	0.5	0.5	0.9	7.6
Carbon by burn-off, gm	6.4	7.2	12.0	26.5	25.1	18.0	28.2	28.0	32.7
Total recovered, gm	244.4	256.3	437.1	434.2	430.6	428.7	409.5	421.8	470.6
Losses by difference, gm	5.6	6.7	—0.7	6.5	10.4	1.3	9.5	9.2	4.4
Per cent losses on charge	2.2	2.5	—0.16	1.47	2.36	0.3	2.3	2.1	0.9
Distillation data									
Gasoline, 52-410 F, gm	84.0	62.3	76.6	80.9	78.8	81.5	78.3	77.7	106.1
Residue, gm	104.8	113.4	115.2	102.6	105.5	137.1	98.8	103.0	132.9
Condensable gases, gm	31.7	21.9	169.4	157.3	115.9	136.8	142.8	163.2	145.5
Wt. per cent gasoline, 52-410 F	33.6	23.7	28.9	30.4	30.2	30.7	30.7	29.2	33.2
Wt. per cent conversion of oil chgd.	57.3	52.7	55.9	61.3	59.5	48.1	61.1	61.0	56.1
Wt. per cent ultimate yield, gasoline	58.6	45.0	51.6	49.6	50.8	63.8	50.2	47.9	59.2
Wt. per cent carbon laydown	2.6	2.7	4.5	10.0	9.6	6.8	11.1	10.5	10.2
Volume per cent gasoline	38.3	27.0	33.0	34.7	34.4	35.0	35.0	33.3	37.8
Volume per cent conversion of oil charged	65.3	60.0	63.7	70.0	67.8	54.8	69.7	69.5	63.9
Volume per cent ultimate yield	66.8	51.3	58.8	56.5	57.9	72.7	67.2	54.6	67.4

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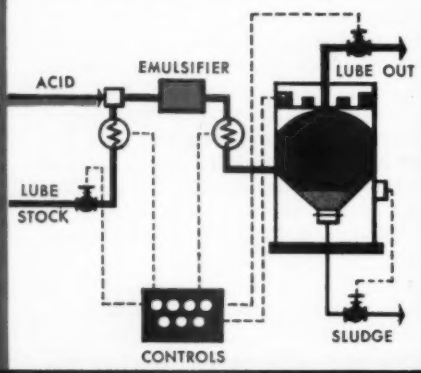

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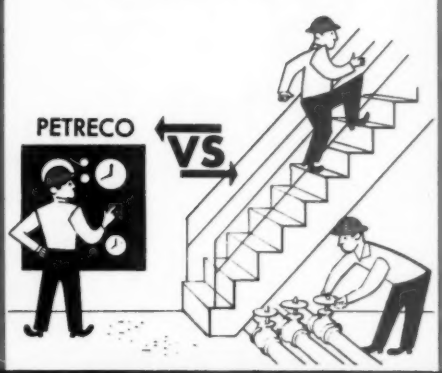

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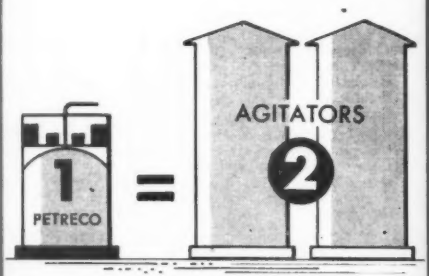

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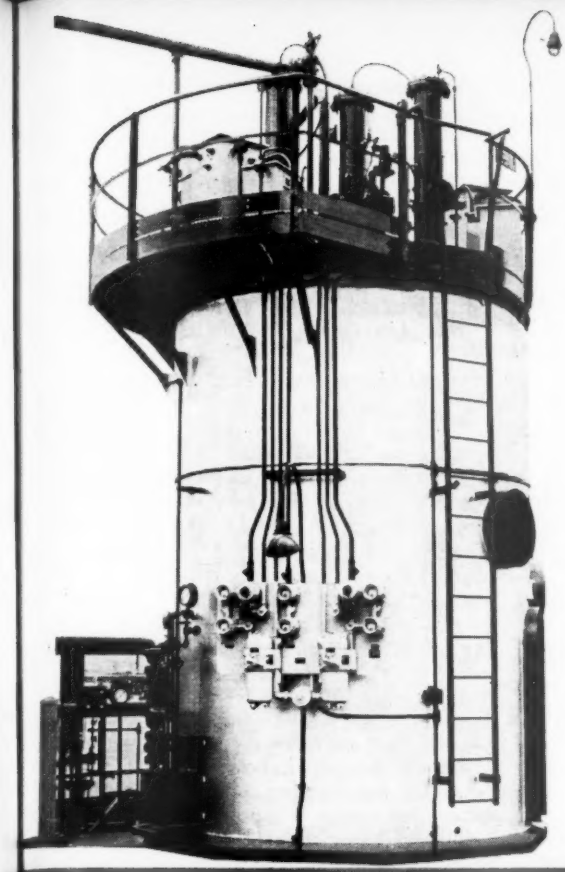

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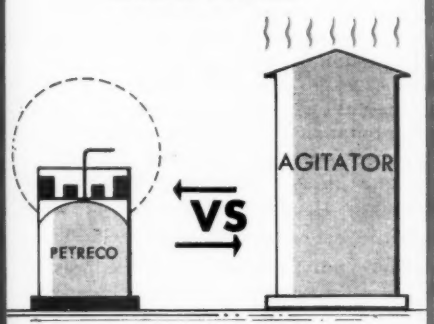

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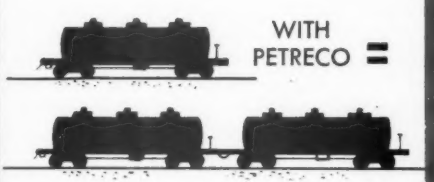

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paratively poor. The maximum gasoline production occurred at 65 per cent conversion and was only 24 per cent. Its octane rating was a mediocre 60.7 ASTM, clear and 68 Research, clear. The carbon laydown was the most excessive of any catalyst studied being 22 per cent at maximum gasoline production and 30 per cent at 80 per cent conversion, 543 C, (1010 F).

Five runs were carried out with a silica-magnesia catalyst over a temperature range of 403 to 528 C, (757 to 982 F). Maximum gasoline production, 32 per cent, was obtained at any conversion from 56 to 70 per cent, the corresponding temperature range being 445 C to 480 C, (833 to 896 F). Octane rating of the product gasoline was comparable to that obtained by catalytic cracking.

A comparison of these results with that reported for Houdry catalyst in a conventional fixed bed catalytic cracking operation in Table 4, Run 9 will show that none of them equal it in yield of gasoline and only Filtrol, synthetic bead and silica-magnesia equal it in octane rating of product gasoline.

A series of runs with the Houdry synthetic aluminum-silicate catalyst in a catalytic polyforming operation at 900 psig with n-butane gave a maximum gasoline yield per pass of 44.6 per cent at 51.8 per cent conversion and the maximum is reported as Run 16, Table 4. Octane rating of the product gasoline of 79.7 ASTM, clear, and 85.4 Research, clear, was considerably higher than that obtained by conventional catalytic cracking. These data indicated that Houdry catalyst was the most effective in catalytic polyforming and further work was limited to this catalyst.

A study of the use of several different hydrocarbons as the outside gas was carried out at 900 psig and the runs giving the highest yields of gasoline are presented in Table 4 and 5. Eight runs made with propane at conversions from 28.5 per cent, 312 C, (594 F) to 77 per cent, 457 C, (855 F) gave a maximum yield of gasoline of 38.7 per cent at 60 per cent conversion. The octane rating of the gasoline so produced showed no improvement over conventional catalytic cracking.

Isobutylene as the outside gas was studied in a series of fifteen runs. Maximum gasoline yields of 40 to 45 per cent were obtained at conversions ranging from 30 to 88 per cent. The octane rating of the gasoline product compared favorably with that obtained with any other outside gas in catalytic polyforming and with that from catalytic cracking. Maximum values of 81.4 ASTM, clear, and 92.7 Research, clear, were obtained.

Two runs, Nos. 14 and 15 in Table 4, were made to ascertain the role of isobutylene polymerization in catalytic polyforming. In Run 14, n-butane was substituted for the gas oil and in Run 15 only isobutylene was charged. A considerable yield of gasoline was obtained in each case indicating that polymerization of the isobutylene to a material boiling in the gasoline range and higher will occur under the catalytic polyforming conditions used in this investigation.

TABLE 6. Catalytic polyforming with a mixed gas at low mol ratios.

Run number	27	28	29	30	31
Type of catalyst	Houdry	Houdry	Houdry	Houdry	Houdry
No. of previous runs on catalyst	51	32	6	10	8
Average reactor temp., C	458	455	449	472	460
Average operating pressure, psig	0	900	1500	1500	2000
Liquid space velocity, hr^{-1}	4.65	5.03	4.7	4.5	4.3
Mol ratio	2.87	3.33	2.79	3.88	3.23
Material charged					
Outside gas, type	Mixed gas	Mixed gas	Mixed gas	Mixed gas	Mixed gas
Outside gas, gm	158.4	181	152	218	202
Charge stock, gm	267	263	264	272	304
Total charge, gm	425.4	444	416	490	506
Recovered material					
Hydrocarbon liquid prod., gm	176.3	164.9	216.0	222.7	263.4
Condensable gases, gm	208.5	208.0	127.4	187.6	170.7
Permanent gases, gm	22.6	35.0	23.5	31.2	24.2
Oil from catalyst, gm	2.9	1.0	8.5	3.3	8.3
Carbon by burn-off, gm	11.5	28.1	36.7	53.5	36.5
Total recovered, gm	421.8	437.0	412.1	498.3	503.1
Losses by difference, gm	3.6	7.0	3.9	—8.3	2.9
Per cent losses on charge	0.85	1.58	0.9	—1.7	0.6
Distillation data					
Gasoline, 52-410 F, gm	71.0	81.8	92.5	102.5	91.8
Residue, gm	140.1	115.0	85.4	87.8	126.2
Condensable gases, gm	134.0	147.5	144.4	167.2	167.3
Wt. per cent, gasoline 52-410 F	26.6	31.1	35.0	37.7	30.2
Wt. per cent conversion of oil charged	46.4	55.9	64.4	66.5	55.9
Wt. per cent ultimate yield, gasoline	57.4	55.7	54.4	57.7	54.0
Wt. per cent carbon laydown	4.3	10.7	13.9	19.7	12.0
Volume per cent gasoline	30.3	35.4	39.9	43.0	34.4
Volume per cent conversion of oil charged	52.9	63.7	73.4	75.7	63.8
Volume per cent ultimate yield	65.4	63.5	62.0	65.7	61.5

A series of eight runs at 900 psig was made using isobutane as the outside gas. The gasoline yield held relatively static between 29 and 31 per cent over a conversion range of 48 per cent, 425 C (797 F) to 71 per cent, 490 C, (914 F). The octane rating of the gasoline obtained was 80.2 ASTM, clear, and 87 Research, clear, considerably higher than catalytically cracked gasoline.

Table 5 presents the maximum yield runs from a series of determinations with isobutane as the added outside gas investigating the role of pressure in catalytic polyforming. In this series, the yields were not especially attractive nor did they vary greatly with pressure. It should be noted, however, that the catalytic polyforming operation could be carried out at a much higher space velocity than conventional catalytic cracking. The gasoline produced at the higher pressures had the higher octane ratings.

Having noted certain advantages with both paraffins and olefins in catalytic polyforming, it was decided to employ as the outside gas a paraffin-olefin gas mixture similar in composition to a refinery cracked gas. The mixture used had the following composition: 30 per cent n-butane, 10 per cent isobutane, 20 per cent isobutylene, 20 per cent propane and 20 per cent propylene. The remainder of the work reported in

TABLE 7. Effect of mol ratio and pressure on catalytic polyforming with mixed gas.

Run number	32	33	34	35	36	37	38	39	40	41	42
Type of catalyst	Houdry	Houdry	Houdry	Houdry	Houdry	Houdry	Houdry	Houdry	Houdry	Houdry	Houdry
No. of previous runs with catalyst	4	15	27	32	35	45	41	43	40	42	44
Average reactor temp., C.	473	449	391	440	421	440	411	455	467	436	428
Average operating pressure, psig	1500	1500	1500	1500	1500	1500	0	300	900	1200	2000
Liquid space velocity, hr^{-1}	5.04	5.2	4.63	4.5	4.6	4.17	4.39	4.85	4.33	4.39	4.43
Mol ratio	2.61	4.15	7.12	9.45	10.47	15.12	9.84	9.85	10.12	10.27	9.73
Material charged											
Outside gas, type	Mixed gas	Mixed gas	Mixed gas	Mixed gas	Mixed gas	Mixed gas	Mixed gas	Mixed gas	Mixed gas	Mixed gas	Mixed gas
Outside gas, gm	182	226	282	311	341	415	353	321	315	322	311
Charge stock, gm	337	264	192	156	158	133	174	158	151	152	155
Total charge, gm	519	490	474	467	499	548	527	479	466	474	466
Recovered material											
Hydrocarbon liquid prod., gm	147.9	165.9	248.5	201.1	262.9	138.0	149.8	166.3	188	181.3	228.3
Condensable gases, gm	199.2	225.4	173.7	198.9	186.3	339.0	338.7	248.7	220.3	218.3	164.8
Permanent gases, gm	107.4	41.3	16.3	32.8	13.9	34.2	12.6	21.5	25.5	33.8	26.0
Oil from catalyst, gm	8.9	16.5	13.6	1.9	5.5	1.0	5.0	4.0	1.8	1.7	2.2
Carbon by burn-off, gm	51.9	38.8	15.8	32.0	21.2	27.9	15.9	23.0	31.6	30.3	25.0
Total recovered, gm	515.3	487.9	467.9	466.7	489.8	540.9	522.0	463.5	467.2	465.4	446.3
Losses by difference, gm	3.7	2.1	6.1	0.3	9.2	7.1	5.0	15.5	—1.2	8.6	19.7
Per cent losses on charge	0.7	0.4	1.3	0.06	1.8	1.3	0.95	3.2	—0.3	1.8	4.2
Distillation data											
Gasoline, 52-410 F, gm.	101.2	88.0	72.2	76.8	73.8	59.3	44.3	70.2	72.7	74.2	72.1
Residue, gm	70.9	79.3	113.8	58.2	63.8	49.3	107.2	48.0	40.6	45.7	55.0
Condensable gases, gm	143.6	175.5	173.1	226.4	255.1	335.6	290.5	274.1	267	260.2	230.9
Wt. per cent gasoline 52-410 F	30.1	33.3	37.6	49.2	46.6	44.6	25.5	44.4	48.0	48.8	46.6
Wt. per cent conversion of oil charged	76.3	63.7	33.6	61.5	56.2	62.2	35.5	67.1	71.9	68.8	63.2
Wt. per cent ultimate yield, gasoline	39.5	52.3	112.0	80.0	83.0	71.8	71.8	66.2	66.8	71.0	73.8
Wt. per cent carbon laydown	15.4	14.7	8.2	20.5	13.4	21.0	9.1	14.5	20.9	20.0	16.1
Volume per cent gasoline.	34.3	38.0	42.9	56.1	53.2	50.9	29.0	50.6	54.7	55.6	53.1
Volume per cent conversion of oil charged	87.0	72.5	38.3	70.0	64.0	70.9	40.5	76.5	81.9	78.4	72.0
Volume per cent ultimate yield	45.0	59.7	128	91.2	94.6	81.8	81.8	75.5	76.1	81.0	84.0

XUM

Tables 6, 7, and 8 was done with this gas mixture.

A series of thirty runs was carried out to determine the effect of pressure with mixed gas catalytic polyforming and representative data are tabulated in Table 5. Up to 1500 psig, the gasoline yield increased with pressure. With mixed gas catalytic polyforming, the product gasoline had an octane rating of about 80 ASTM, clear, and 85 Research, clear, which remained essentially unchanged regardless of the conditions of pressure or mol ratio employed.

Runs 32 to 37 in Table 7 are typical runs taken from a study to determine the effect of mol ratio of outside gas to gas oil in the charge. The pressure employed was 1500 psig and mixed gas was used. The mol ratio was increased from 2.61 to 15.77 and a steady increase in gasoline yield was noted up to mol ratio of 10. Above that value no further increase was obtained.

As a mol ratio of 10 seemed most effective, a study of the effect of pressure at this mol ratio was undertaken. Runs 38 to 42 in Table 7 show the effect of varying pressure from 0 to 2000 psig when the mol ratio of the mixed gas to gas oil is about 10. Maximum gasoline yield of about 48 per cent was obtained at 900-1200 psig and may be compared with the 38.8 per cent obtained with this catalyst in conventional catalytic cracking, Run 9, Table 4.

Several runs with mixed gas at 1500 psig having conversions of about 50 per cent are tabulated in Table 8 and compared with conventional catalytic cracking at the same conversion. Changes in space velocity and mol ratio, the effect of which has been noted above, account for the differences in gasoline yield. An increase of 10 — 15 per cent in gasoline yield at this conversion is noted for catalytic polyforming.

Table 3 shows that clear octane ratings of gasolines produced by catalytic polyforming with mixed gas average 6 to 7 units higher than that obtained by catalytic cracking and are not greatly affected by changes in pressure or mol ratio.

TABLE 8. Effect of space velocity on catalytic polyforming with mixed gas.

Run number	43	44	45	46	47
Type of catalyst	Houdry	Houdry	Houdry	Houdry	Houdry
No. of previous runs on catalyst	49	9	37	34	46
Average reactor temp., C	413	407	397	419	421
Average operating pressure, psig	Atm	1500	1500	1500	1500
Liquid space velocity, hr^{-1}	0.75	2.82	4.57	4.67	3.96
Mol ratio — gas to oil	—	5.88	10.07	10.2	15.77
Material charged					
Outside gas, type	None	Mixed gas	Mixed gas	Mixed gas	Mixed gas
Outside gas, gm	—	271	316	324	432
Charge stock, gm	264	223	152	154	132
Total charge, gm	264	494	468	478	564
Recovered material					
Hydrocarbon liquid prod., gm	233.7	213.5	231.3	206.1	221.6
Condensable gases, gm	4.6	214.8	200.2	216.7	252.8
Permanent gases, gm	3.5	23.6	9.85	13.1	48.0
Oil from catalyst, gm	5.0	10.7	9.4	5.5	2.2
Carbon by burn-off, gm	6.45	30.2	21.8	21.0	29.4
Total recovered, gm	253.25	492.8	472.55	462.4	574.0
Losses by difference, gm	10.75	1.2	—4.5	15.6	—10.0
Per cent losses on charge	4.46	0.24	—0.9	3.3	1.7
Distillation data					
Gasoline, 52-410 F, gm	86.3	93.4	67.5	72.8	62.2
Residue, gm	120.6	90.4	70.8	69.7	51.3
Condensable gases, gm	26.5	196.8	152.6	193.6	313.8
Wt. per cent gasoline, 52-410 F	32.7	41.8	44.5	47.3	47.1
Wt. per cent conversion of oil charged	52.4	54.7	47.2	51.2	59.5
Wt. per cent ultimate yield, gasoline	62.4	76.5	94.2	92.3	79.3
Wt. per cent carbon laydown on oil charged	2.44	13.5	14.3	13.6	22.2
Volume per cent gasoline	37.3	47.7	50.7	53.9	53.6
Volume per cent conversion of oil charged	59.7	62.3	53.8	58.3	67.8
Volume per cent ultimate yield	71.1	87.2	107.3	105.2	90.3

Summary

Results obtained in this investigation of catalytic polyforming may be summarized as follows:

1. Houdry synthetic aluminum-silicate cracking catalyst appears to be the most effective of those tested. Synthetic bead and silica-magnesia are relatively good catalysts in this process. Cyclocel, Filtrol, HF activated alumina, chrome-alumina and molybdenum-alumina are not especially effective.

2. Gasoline in higher yield and octane number than that from catalytic cracking can be obtained with catalytic polyforming when an olefin or a mixed olefin-paraffin gas mixture is employed. Paraffin hydrocarbons as the outside gas seem to be more effective in enhancing the octane rating than increasing the yield.

3. Using a paraffin-olefin gas mixture similar in composition to a C_3-C_4 refinery cracked gas, gasoline yields and octane ratings exceeding conventional catalytic cracking can be obtained at 300 to 2000 psig and mol ratios of gas to oil of about 10 in a catalytic polyforming operation.

Acknowlegments

The authors acknowledge with thanks the courtesy of the Phillips Petroleum Company under whose sponsorship this work was carried out. The time and advice of F. E. Frey and C. J. Helmers who coordinated the work for Phillips is appreciated by the authors.

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* * *

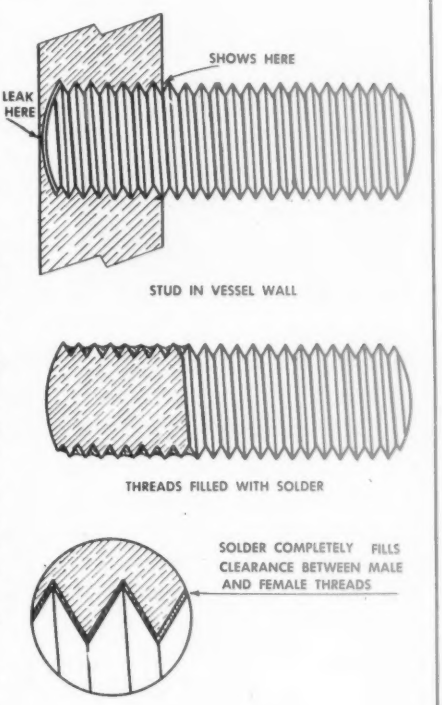
Plant Aids

Repair Thread Leak‡

F. R. STIVISON**

Several leaks developed where stud bolts were screwed into pressure vessels. In some instances the holes were apparently drilled completely through the plate and in others loss of metal from corrosion caused pressure to reach the stud hole. In either case gas or fluid reaching the stud hole would follow the path of the threads and show up as a leak at the surface. As bolt threads are not tapered additional tightening of the stud has little effect. We have had 100 per cent success with the following method:

Stud is thoroughly cleaned and tinned with solder for a length equal to the depth of the hole it is to be screwed into. Solder is then added until the threads are almost completely filled. After the stud has cooled it is screwed into place. The solder will completely fill the clearance space between the threads of the hole and those of the stud effectively sealing off any leakage into the bottom of the hole. This method has an advantage over seal welding as the stud can be easily removed if desired.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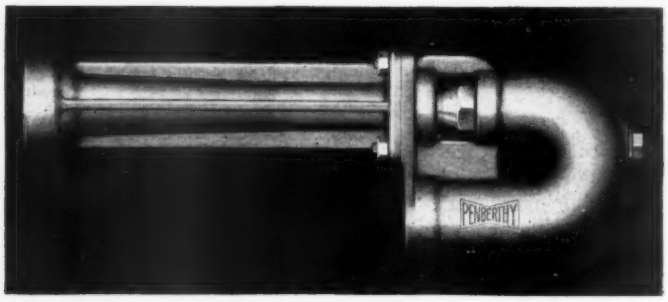

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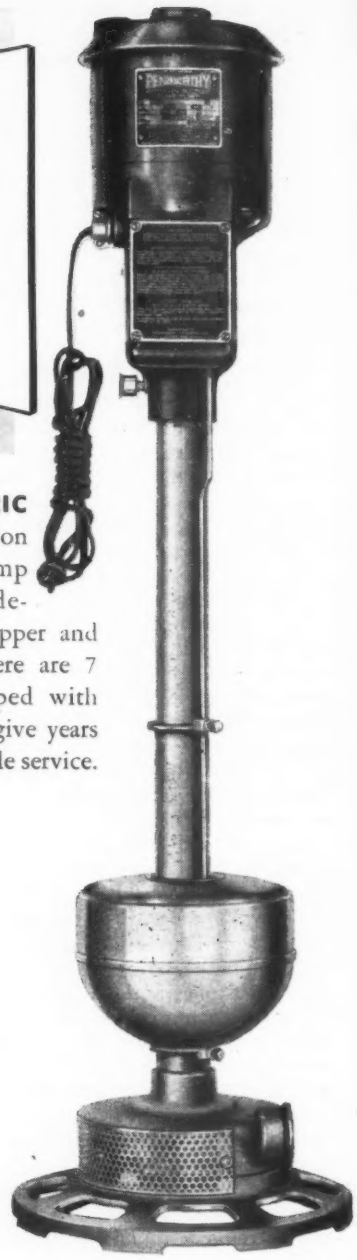

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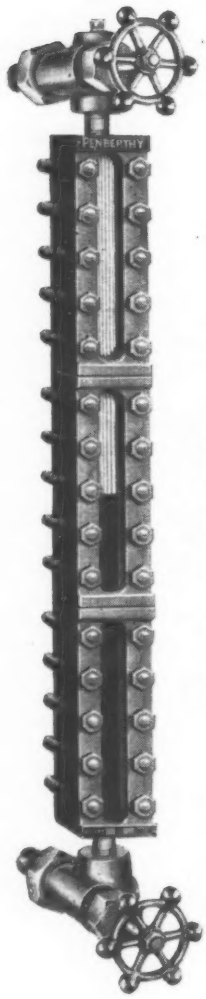

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Trends in Refinery INSTRUMENTATION

PART 11—Liquid level measurement and control

S. D. ROSS* and W. W. DRAKE*

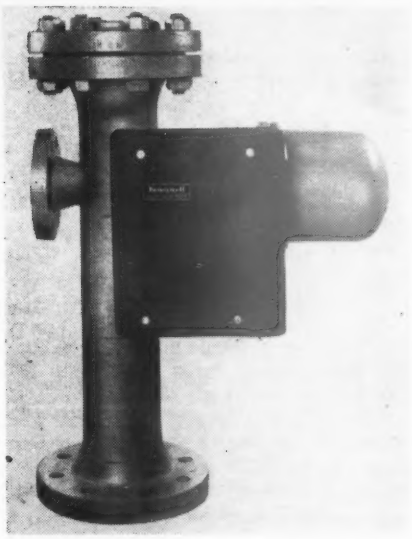

FIG. 1. External view of displacement float device using force balance principle.

ANOTHER liquid level device using the displacement or buoyancy principle is a type known as a force balance system, shown in Fig. 1. This is a later and improved development, eliminating some of the deficiencies of the torque tube system. It is said to be much more sensitive a device, and also to have a much wider range of operation.

A cut-away view of the system is shown in Fig. 3. Note that coupling from the displacer to the pneumatic pilot is much closer than in the torque tube arrangement, since the support rod is no longer needed. The displacer arm (equivalent to the rod inside the torque tube) is directly linked to the pneumatic pilot. Both these design features mean greater accuracy through increased sensitivity, and less chance for frictional effects or instrument lags and dead zones resulting from excessive mechanical linkages. As in the torque tube system, no stuffing box or packing gland is necessary, since a flexible sealing bellows is used between internal and external atmospheres.

Construction. The welded steel detector cage is connected, as shown schematically in Fig. 2, to the vessel in which the level is being measured. The stainless steel cylindrical displacer within the cage (Fig. 3) has fastened to its upper end a rod which extends through the stainless steel flexible bellows, out of the cage. The portion of the rod projecting from the cage extends through a yoke and carries removable zero setting weights and provisions for hanging calibrating weights. Vertical movement of the displacer causes rotation of the yoke shaft, which is supported by self-aligning ball bearings. Rotation of this yoke is transmitted through the base plate by an extension of the yoke shaft.

Mounted on this extension is a lever on the top surface of which is a knife-edge pivot. A small scale on the lever is calibrated in specific gravity, and the knife edge is adjustable laterally along this scale to permit the device to be adjusted for specific gravity.

A second lever, mounted above the first one, is pivoted at the other end and rests on the knife edge just described. Mounted above these levers are two bellows assmblies. The one on the right is the damping bellows; the one on the left, the pneumatic balancing bellows.

Operation. An increase in liquid level in the detector cage increases the buoyancy of the displacer and causes a moment displacement in an upward direction. This upward movement results in a clock-wise rotation of the bell crank, its extension shaft, and consequently the lever carrying the knife-edge pivot. Upward movement of the pivot causes upward movement of the second lever against the pneumatic and balancing bellows. This upward bellows movement opens the supply air port and air is admitted to the interior of the bellows. This air pressure will continue to increase until sufficient force is created to return all of the components of the system to their original positions before the change in level occurred. An opposite sequence of operation takes place if the measured level decreases.

The damping bellows serves to eliminate oscillation or hunting by preventing the pneumatic balancing bellows from functioning as a piston motor with minute changes in level. Basically,

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FIG. 2. Typical installation of displacement float device showing separate record-controller.

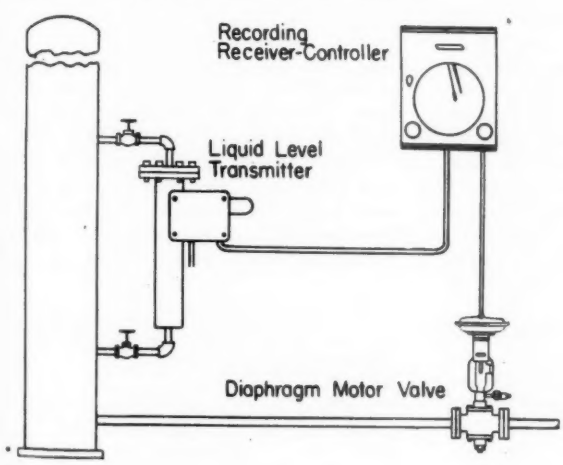
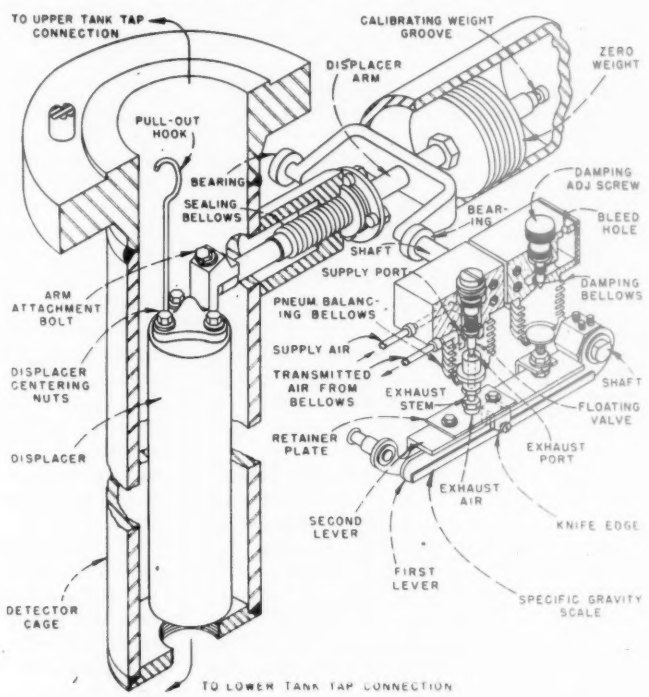


FIG. 3. Cutaway view of force balance device.



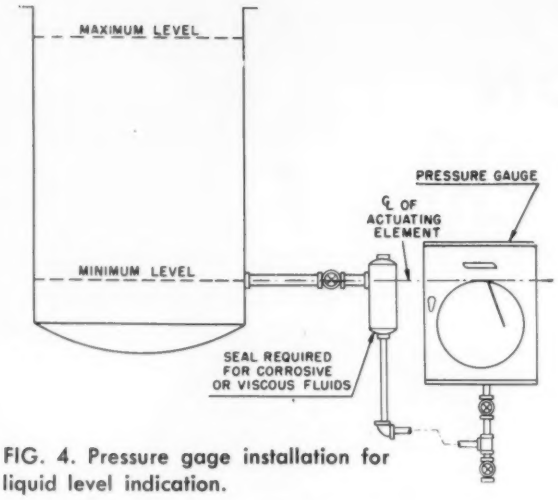


FIG. 4. Pressure gage installation for liquid level indication.

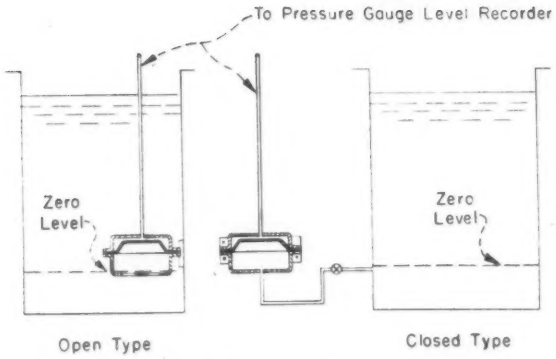


FIG. 5. Diaphragm box installation.

this unit consists of a liquid filled flexible envelope with a centrally located orifice. As level changes occur, the liquid is forced through the orifice from one side to the other. Flow lag of this liquid through the restriction provides the necessary damping action.

Hydrostatic Pressure Methods

Where liquid levels must be measured and controlled over wide ranges, free float and displacement-float mechanisms are of little or no use. Instead, one of the earliest devices, the simple differential manometer, is used to a great extent. Historically appearing after the differential manometer, but slightly simpler in principle, is the method using a simple pressure gage.

Pressure Gage Method. Use of a pressure gage for indicating and/or controlling liquid levels is usually limited to open vessels. In closed vessels, pressures due to factors other than the hydrostatic head of the liquid, such as vapor pressures, make a reading incomprehensible unless elaborate calibration curves and corrections are employed.

The gage method, (Fig. 4), as well as other static pressure measuring methods in open vessels, is based on the relationship $P = hgw$, where P is the pressure head, h the height of the liquid above a reference point, g the specific gravity of the liquid, and d the density of water at 60 F. Thus any instrument that measures pressure can be calibrated in terms of height of liquid level.

When a simple pressure gage is used, the center line of the element should be at the same elevation as the pressure tap of the vessel. Otherwise, head effects in the gage line must be compensated by recalibration or some other method.

This simple static pressure method using a properly calibrated pressure gage lends itself readily to the use of non indicating pressure controls for "high-low" level control. One type, for example, contains a mercury switch, which can turn on an electric inlet pump when the level drops to the low limit, and turn the pump off when the high limit is reached.

Diaphragm Box Method. Another level system utilizing the pressure gage employs a diaphragm box primary element. The box, immersed to the minimum level point and connected by a tube to the pressure gage, contains a relatively large amount of air which is retained by a flexible diaphragm. The pressure exerted by the head of liquid against the underside of the diaphragm compresses the air within the box until the air pressure on the upper side is equal to the liquid pressure. The gage measures the air pressure but is calibrated in terms of liquid level.

As shown in Fig. 5, there are two types of diaphragm box: The open type, which is immersed in the liquid in the vessel, and the closed type, which is mounted externally and connected to the vessel by a short length of piping. The open box can be used with liquids containing some suspended matter, but the closed box is used only with clear liquids. Neither box should be located more than 250 ft from the gage.

Air Purge Method. This system, also involving a pressure gage, does not limit the location of the gage and can be used for corrosive liquids even with relatively large amounts of suspended matter. An air line is immersed in the liquid to the minimum level, as shown in Fig. 16, with the pressure and volume of air supply controlled so that slow bubbling (0.2 to 2.0 cu ft per hour) will occur when the vessel is filled.

To regulate air supply accurately a small rotameter with needle valve is recommended, together with a differential pressure regulator connected across the rotameter. The air pressure in the air line is then equal to the back pressure exerted by the head of liquid. Measurement of this air pressure is, therefore, equivalent to measurement of the static pressure of the liquid — i.e., the liquid level.

Where immersion of the air line is not desirable, because of agitator blades or other reasons, the air line can be tapped into the side of the vessel at the point of zero level.

Installation Considerations. Generally speaking, static pressure methods in open vessels have a minimum range of measurement of 0 to 5 in. of water. The maximum range is seldom above 250 ft.

When using the pressure gage method with liquids that are corrosive or viscous, suitable sealing equipment and a sealing fluid must be used. This arrangement is shown in Fig. 4. It must also be remembered that volumetric measurement in spherical or horizontal cylindrical tanks is not a linear function of static head, and as a result, most gages in this service are either calibrated in inches of water, or have a few widely spaced scale markings to indicate relative height of level.

With diaphragm box methods there is also the problem of pressure variations due to changing temperatures of the entrapped gas. Compensation for such effects is seldom used, however. Because of the nature of the flexible diaphragm, this type of instrument is unsuited for measurement in boiling liquids, and in fact, 160 F is usually the maximum temperature limit.

Differential Pressure Systems. The mechanical or electrical, mercury actuated, differential pressure flow meter is ideally suited for liquid level measurements in open or closed vessels. Among the advantages offered by mercury manometers are: (1), standard production items are available for pressures up to 5000 psi; (2), they can be supplied with all the various modes of control, such as on-off, proportional plus reset plus rate; and (3), they use standard flow meter parts, used to a great extent in all refineries, thus simplyfing stocking of spare parts.

Open Vessel Consideration.† Mercury differential systems in open vessel work fall into three main classifications: Systems without suppression, systems with suppression when the suppressed

†There is available, upon request, a technical bulletin describing in detail the installation and calibration of various liquid level instrumentation systems, with particular emphasis on differential pressure methods in open and closed vessels. Because of this, the discussion here is limited to primarily a summary. Copies of the bulletin, No. 75-2, are available to those further interested, at any Honeywell branch office, or by writing to Minneapolis-Honeywell Regulator Company, Wayne and Windrim Avenues, Philadelphia 14, Pa.

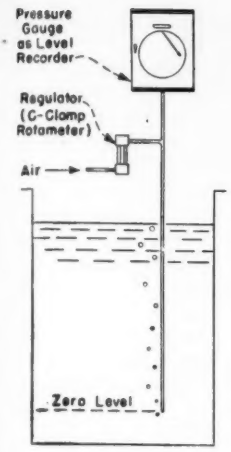


FIG. 6. Air purge system installation.

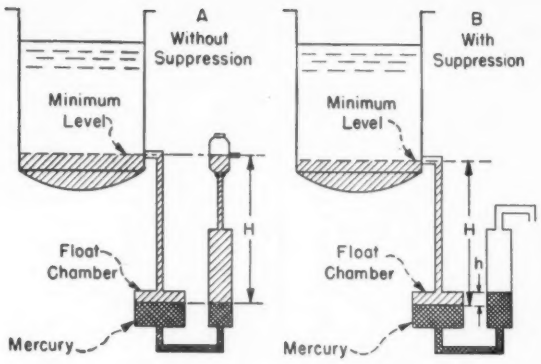


FIG. 7. Differential pressure systems with and without suppression.

head is less than the measured head, and systems where the suppressed head is greater than the measured head.

The basic piping arrangements of systems with and without suppression are illustrated in Fig. 7. Note that without suppression, a leg is required above the low pressure (range tube) side of the meter that extends to the level of the vessel top. This leg is filled with fluid of the same specific gravity as the fluid in the high pressure (float) side of the meter. Thus the effects of the weight of the liquid between the vessel top and the meter are balanced out.

In the system shown "with suppression," there is no leg above the range tube side of the meter. Instead, additional mercury, of a weight equal to the weight of the liquid in the leg above the float chamber, is added to the range tube. In this fashion, the head due to liquid in the float chamber leg is compensated.

The system described in the preceding paragraph is that of "suppression when the suppressed head is less than the measured head." Now take, for example, a water tank, whose height above ground, where the meter body is situated, is much greater than the distance between maximum and minimum level. In this case, the head attributable to liquid in the float chamber leg is much greater than the head due to liquid in the tank. For this reason a fairly large amount of mercury has to be added to the range tube side to offset this head.

The method of adding this mercury is usually as follows. The amount of additional mercury is first computed. Then the meter body is filled with the standard amount of mercury that is specified for use without suppression, and water or sealing liquid added to the high pressure (float chamber side) piping. Connection is then made between the high pressure side and a source of compressed air, and the compressed air forces the meter to read full scale. Additional mercury is added to the range tube until the instrument read zero.

This operation is repeated until the total amount of additional or "suppression" mercury has been added and the instrument reads zero. The compressed air supply is then disconnected and the high pressure side of the instrument connected to the line leading down from the tank or elevated vessel top (point of minimum level).

A good precaution is to locate a mercury trap in the piping between the float chamber and the riser to the tank, in order to catch the excess mercury in the event that head of liquid should be lost.

Closed Vessel Considerations. As in the case of open vessel measurement, both electric and mechanical differential pressure meters can be used. Basic piping for the two types is shown in Fig. 8. Both high and low pressure sides of the meter are connected into the vessel, and thus the head effects due to factors other than liquid level are cancelled out, as they appear equally on either side of the mercury.

With the liquid in the vessel at minimum level, the meter body is subjected to a differential pressure equivalent to the head *(H4)* in the outer leg. As the level rises in the vessel, this differential pressure *decreases* to zero at the maximum level connection. This relationship naturally gives us a reverse reading, and because of this, modifications are necessary.

In the case of the electric meter body, the problem is quite simple. Reversing connections of the two power leads of the inductance bridge circuit reverses the response of the receiving instrument, and zero on the scale corresponds to minimum liquid level. With the reversed connections, the meter body can be connected to the vessel as shown in the diagram (high pressure side to outer leg), and the float will rise as liquid level rises.

In the case of the mechanical meter body, reversal of instrument response is brought about by "dropping" the range tube below the float chamber. The outer leg is connected to the range tube, while the inner leg (going to the minimum level tap) is connected to the high pressure (float chamber) side. Thus the float is in its normal upper position for minimum level, and moves downward with increasing level (decreasing differential). The dropped range tube provides the necessary chamber for mercury displaced from the chamber as the liquid level rises. A system using a mechancial meter body with sealing fluid is shown in Fig. 9.

Two main types of suppression are used with differential pressure instruments measuring levels in closed vessels. These two methods are mercury

FIG. 9. Diagram showing piping connections for mechanical metering system.

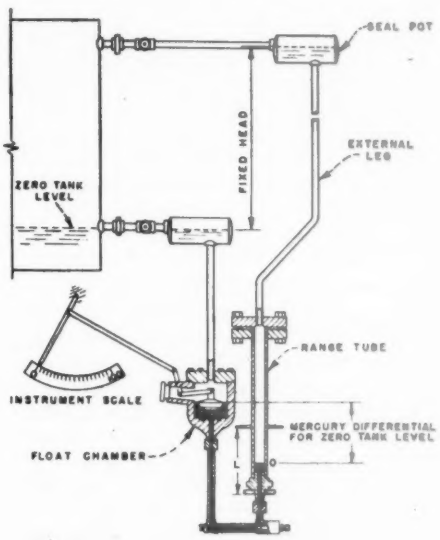
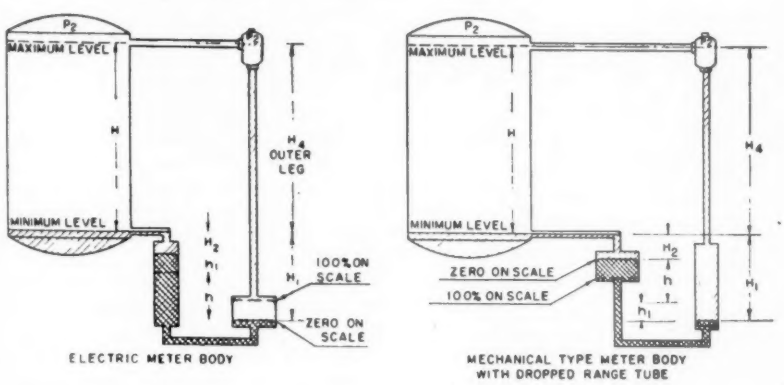


FIG. 8. Differential pressure systems on closed vessels.



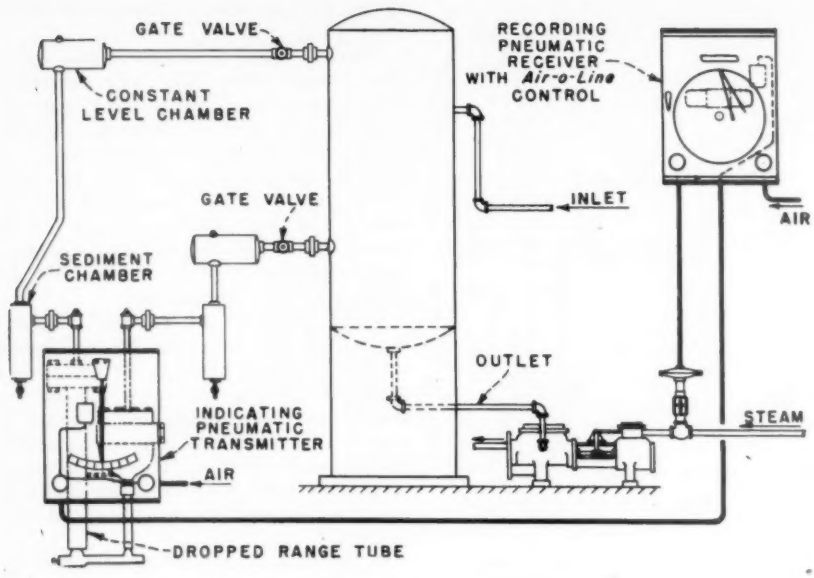


FIG. 10. Typical liquid level installation using pneumatic transmission.

suppression and instrument suppression, with the latter accomplished by a mechanical adjustment of a linkage within the instrument case. Suppression is necessary due to the fact that without it, the meter does not read full scale when the specific gravity of the liquid in the outer leg does not equal the specific gravity of the liquid in the vessel. This condition usually arises from the use of sealing liquids, or when the liquid in the vessel is hotter than the same liquid in the outer leg, thereby causing a difference in specific gravity.

Remote Transmission. The electric meter body is inherently suited for remote transmission of liquid level measurements in both open and closed vessels. Operating on the inductance bridge principle, the system uses an ordinary 3-wire cable to connect meter body with receiving instrument. This receiving element may either be a standard, properly calibrated flow meter, or it may be an *ElectroniK* inductance bridge receiver. With the latter, many functions besides recording, indication, and control are possible with the single instrument, such as remote adjustment of set-point and retransmission of data.

A system of instrumentation for remote transmission using the mechanical meter is shown in Fig. 10. Here, a pneumatic bellows in the meter is connected to a matched bellows in the recording controller. This latter instrument is equipped with *Air-O-Line* control regulating the outlet flow from the vessel.

Electrical, Electronic, and Other Methods

Electrode or Conductivity System. The operation of an electrode system can easily be likened to a mercury switch, where the tank electrodes (Fig. 11) corresponds to the switch contacts, and the liquid whose level is being measured corresponds to the mercury. This liquid of course must be capable of conducting an electric current.

Such systems are simple, effective, and accurate, and are easy to install. They are relatively low in cost, and require almost no maintenance. Problems in interface control and foam control are often met by the electrode system.

That control action may be easily instituted by this method is obvious. Either an electrically operated pump, or solenoid valve, or other device may be used to control inlet or outflow.

Inductance Method. A fairly unusual method of liquid level measurement that has a large number of stated advantages has been reported recently. It is said to be unaffected by variations in temperature, pressure, or the physical constants of the liquid under measurements, such as specific gravity, dielectric constant, etc. Checking and calibration of the system can be done without emptying or filling the vessel, and with modifications, the system can be used to apply linearly to odd shaped tanks.

In brief the system consists of a steel float, free to travel up and down inside a non-magnetic (usually plastic) tube, around which are spaced a number of carefully wound coils. The number of turns of wire that make up the coils successively increases as the coils are placed successively one above the other up the length of the tube. The coils are all connected in series, and a steel shell is placed around the entire assembly for protective purposes.

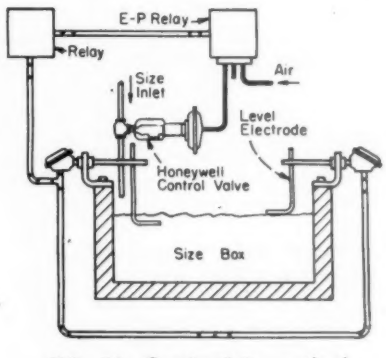


FIG. 11. Conductivity method of level control.

Power supply to the inductance thus formed is from a 1000-cycle constant-current source. A special electronic circuit is used to counteract certain effects that would make it difficult to read level height as the float travels in the coil, changing its inductance. Accuracy and linearity is within 1 per cent of full scale travel, and could undoubtedly be improved. By varying the winding of the individual coils that make up the total inductance, a linear scale could be obtained for the odd shaped tank. Connection to the indicator is by two-wire cable, and of course, control components can be added at the indicator.

Method Using Thermocouples. By mounting two thermocouples side by side in a bin or precipitator hopper, and connecting them in series with opposing polarities, a means for detecting ash or other material level is provided. One couple is mounted in a sealed tube, the other in a tube open to the atmosphere on one side, and the hopper on the other. Negative draft in the hopper draws air through this latter tube, cooling the thermocouple, and thus a differential potential is available from the series hook-up. When ash level rises to a point where the second tube is covered, the draft is cut off, and the thermocouple heats until it reaches the temperature of the first couple. The differential potential disappears, and an alarm can be sounded. With the operating point at zero potential, open circuit conditions will also sound the alarm.

Ultra-sonic Methods. Ultra-sonic, or very high frequency sound waves, can be employed to measure liquid levels, usually in large storage tanks. They operate on the same principle of wartime Sonar, that of measuring the time interval between transmission of a sound energy pulse, its time of travel to the liquid surface, and time of return travel to where it is detected by the receiver. This total time interval can be directly related to the distance between the transmitter-receiver and the liquid level. Such devices can have an accuracy as high as 1/100 in. per foot of distance of sound wave travel.

Method Using Radio-Isotopes. The application of an atomic energy-operated device for measuring catalyst level has been demonstrated successfully in several refineries in the past several years.

Although this measuring element was developed primarily for catalyst level control, it is applicable for the measurement of all liquid levels and fluid densities through container walls, thus eliminating seals, stuffing boxes, and the like. Modifications of the unit can be used to indicate or control liqiud levels of most refinery products, interface between products in pipe lines, and numerous other applications.

The *Gagetron*, one of these measuring devices, is shown with all necessary components in Fig. 12.

Operating Principle. The *Gagetron* operates on the principle that gamma

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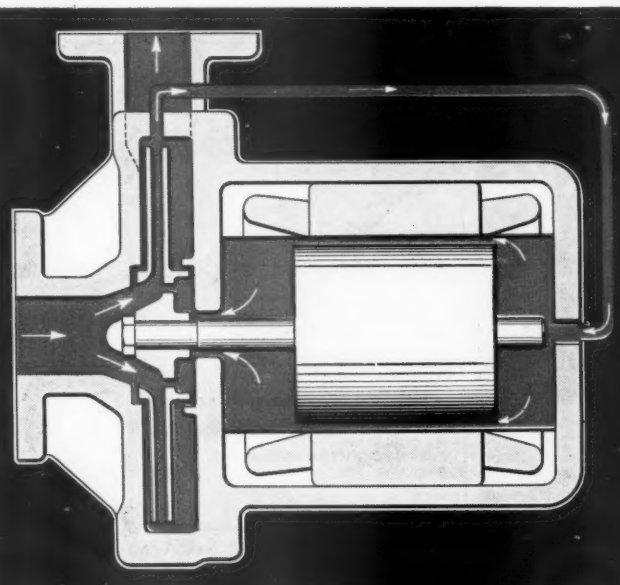

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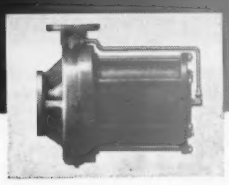

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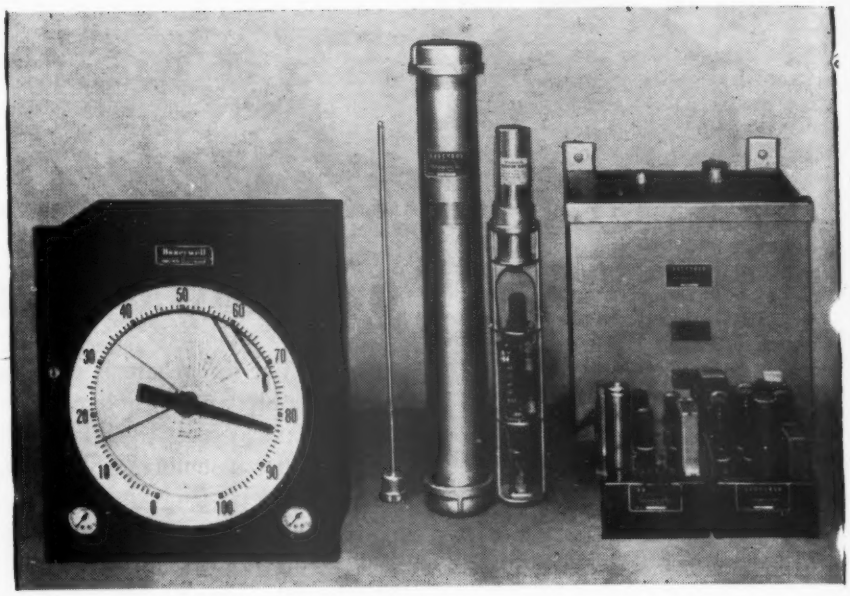

FIG. 12. Components of Gagetron system.

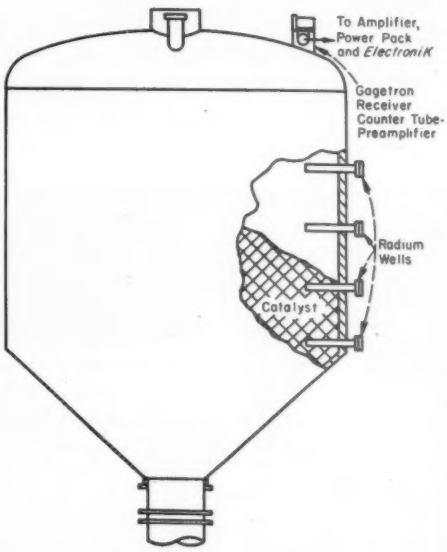

FIG. 13. Cutaway of catalyst surge hopper showing installation of Gagetron elements.

radiations from a radioactive source—in this case radium salts—vary in proportion to the density of any material between the radiation source and a detecting means—a Geiger counter. When used in a catalytic vessel, where the density of the catalyst remains constant, the variations in gamma rays become a function of the thickness or level of the catalyst bed.

The instrument counts the gamma rays received from one or more radioactive sources, which rays pass not only through the material whose level is being measured, but also through any intervening steel vessel walls, or installations. The amount of radium per source and the linear location of source with respect to counter tube are proportional so that no radiation will be detected by the instrument from any source that is covered by two feet of catalyst. For example, 10 radium sources would be required for a 20-ft range. Consequently, when the vessel is empty, the counter receives maximum radiation and vice versa, with the output of the counter tube changing correspondingly. The *Gagetron* circuit measures this output and feeds a corresponding signal to an *ElectroniK* controller.

Fig. 13 shows a typical installation in the reactor surge hopper of a TCC unit. The radium source in the form of a tiny platinum needle is enclosed in a brass capsule, which in turn is screwed on the end of radium support rod. The rod is mounted inside a thermowell. Four radioactive sources and, therefore, four thermowells are used in this case. The counter tube and preamplifier are located outside the vessel wall somewhat above the maximum control level for the catalyst.

The radium sources and counter tube-preamplifier assembly are the only parts of the system mounted on the vessel. Amplifier, power pack and *ElectroniK* recorder are located in a control room; the amplifier may be up to 600 ft from the counter tube.

Oscillator-Gage Glass Combination. This device, which couples modern electronic methods with the old gage or column glass, is said to have accuracies between 0.001 and 0.125 in. of level change. It consists of a simple one-tube oscillator, generating a high frequency alternating current. The current is led to a pick-up loop clamped to a clear gage glass. Any changes in the characteristics of the material in the field of the pick-up detunes the oscillator, causing its output to vary. The change in output, when amplified, can be used to operate relays, motorized valves, high and low limit contacts, etc.

Movement of liquid up and down the gage glass is sufficient to operate the device. While there are no moving parts in the system, it is said to require a clear, visible gage glass tube for proper operation.

Part 12 will be published soon.

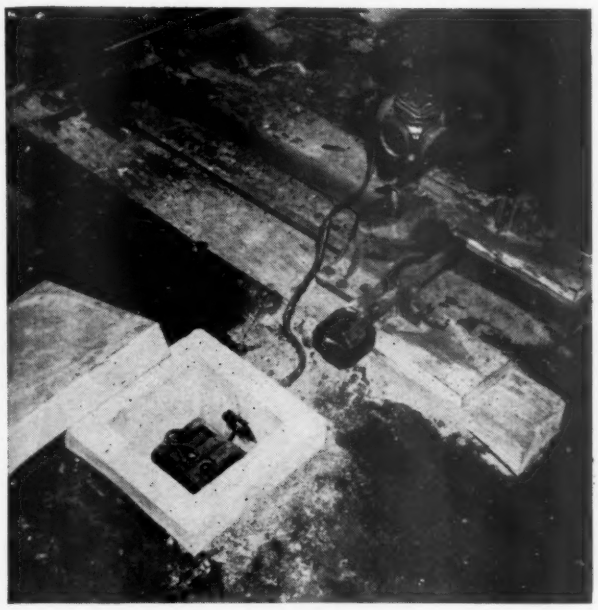

FIG. 1. **COMPLETED** electric switch lamp installation shows battery, battery box, and rigid conduit to switch lamp.

FIG. 2. **MATERIALS** and equipment used to convert oil switch lamps to electric operation.

Switch Lamps Converted to Electric Operation

Fire and explosion conditions reduced by change from oil-burning equipment in refinery's railroad system

E. B. BRIEN*

In order to minimize fire and explosion conditions, a midwestern refinery recently converted its oil-burning railroad switch lamps to electric lamps. As a result, it has not only improved safety, but also lowered operation and maintenance costs notably.

The entire change-over of 135 switches on 45 miles of track in the refinery yard took about two months. The old materials were used as far as possible. The old oil lamps were reconditioned by removing chimneys and welding covers to the top hinge frames and installing commercially available conversion units. Pre-cast concrete battery boxes (18 in. X 18 in. X 21 in., with walls 3 in. thick) topped with wooden covers, and waterproofed with mule hide roofing paper were placed at each switch stand to house special batteries. Inside the boxes, the batteries were made to rest on 2 in. X 2 in. X 10 in. wooden blocks to forestall their malfunctioning from seepage, condensation, or flash flooding.

A one-half inch, water-tight conduit cast into the box connects the battery leads with the switch stand. No. 18, 2-conductor, 600 v, super-service cord runs from the battery to the lamp adapter in the switch stand.

Battery boxes with cast-in bottoms were buried 3 ft from switch stands and from the track (Fig. 1); their tops protrude 6-8 in. above grade level.

In place of the chimneys, No. 10 commercial adapters, consisting of a spacer, lamp base, suspension springs, and 2.7 v, 0.15 amp bayonet-base lamps were installed. Conductor cord, connectors, and fittings complete the installation.

Costs for operating and maintaining the old oil lamps were pronounced. Formerly, they needed cleaning and refilling twice a week, a job for one full-time man. The 135 lamps burned 972 gal of oil per year at a cost of $116. New parts added another $125 per year.

Costs of maintaining the electric lamps has proved comparatively low. Batteries have a service life of 8-11 months at 2.5 v and 0.15 amp drain. Eight and one-half months after installation, no batteries or lamps had yet been replaced. Operating costs were estimated at about $15 per year; servicing costs should add another $15.

Annual savings from the reduced labor, operating, and maintenance phases from the new installations over the old are estimated at $2350 per year.

An intangible benefit from the change to electric lamps was the decrease in switching mishaps because of the added brilliance and visibility of the electric lamps over the old oil lamps. * * *

*Eastern Editor

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Plant Manager R. E. Irwin demonstrates operation of one of controls in oxidizing section of phenol plant.

This infra-red spectrophotometer is indispensable to control adequately the intermediate and final operations.

Canada Makes Phenol, Acetone from Cumene

Refinery-produced cumene converted to two major, several minor materials, meets national requirements

HARRY CHAPIN PLUMMER

Now in routine production of phenol and acetone from petroleum, through oxidation of cumene, the first plant of its kind in the world was formally inaugurated late last spring at Montreal East by B. A.-Shawinigan Ltd., a joint corporate partnership of the British-American Oil Company Limited and Shawinigan Chemicals Limited, the latter a wholly-owned subsidiary of the $290,000,000 Shawinigan Water and Power Company Ltd. Outstanding personalities of the petroleum and chemical industries of Canada and the United States, and of government, science and business of both nations attended the opening ceremonies.

V. G. Bartram, president of B. A.-Shawinigan, the chairman, welcomed the guest of honor, the Honorable Robert H. Winters, Canada's Minister of Resources and Development, who pushed a button that sounded the plant whistle and, so, signalled the start of operations.

Canadian Demand Now Met

The new plant, which occupies five acres of a 20-acre site, with the remainder available for expansion in the development of additional processes and products, has an annual capacity of 13,000,000 lb of phenol, about 8,000,000 lb of acetone, and several by-products, including acetophenone, mesityl oxide and alpha-methylstyrene. Capacity for both phenol and acetone is sufficient to supply the Canadian demand, thus rendering the country independent of imports.

The whole plant is out in the open, not enclosed by buildings. Although this type of design is common in more moderate climates, its use in Canada is unusual. B. A.-Shawinigan engineers decided on open construction to avoid undue vapor concentrations. The prime disadvantage in this type of design is that it requires more than the usual amount of steam piping; in this plant, about 20 miles of steam tracing line is required to assure year-round operation.

B. A.-Shawinigan Ltd. was organized in 1951 by the two companies to produce phenol and acetone by the new Hercules-Distillers oxidation and cleavage process, thereby to make Canada self-sufficient in both chemicals.

V. G. Bartram, of Montreal, president of Shawinigan Chemicals Limited, is president of the new company. The vice president is M. S. Beringer of Toronto, British-American's chairman of the board. Other directors are: Dr. R. S. Jane and P. W. Wright, of Montreal, vice president and secretary, respectively, of Shawinigan Chemicals, and H. T. O'Neill and R. O. Campbell, of Toronto, respectively, vice president and treasurer and chief chemist of British-American Oil Company.

The new plant of B. A.-Shawinigan Ltd. will produce, when the ultimate production rates are reached, some 13,000,000 lb per year of phenol and about 8,000,000 lb of acetone, coupled with the production of some important by-products. Among these will be, as the new plant reaches its potential production figures, approximately 1,000,000 lb of alpha-methylstyrene and several hundred thousand pounds of other products such as acetophenone and mesityl oxide.

Calcium Carbide Diverted Elsewhere

"In Canada, the natural development of the inexpensive generation of electric power in Quebec has until now, dictated

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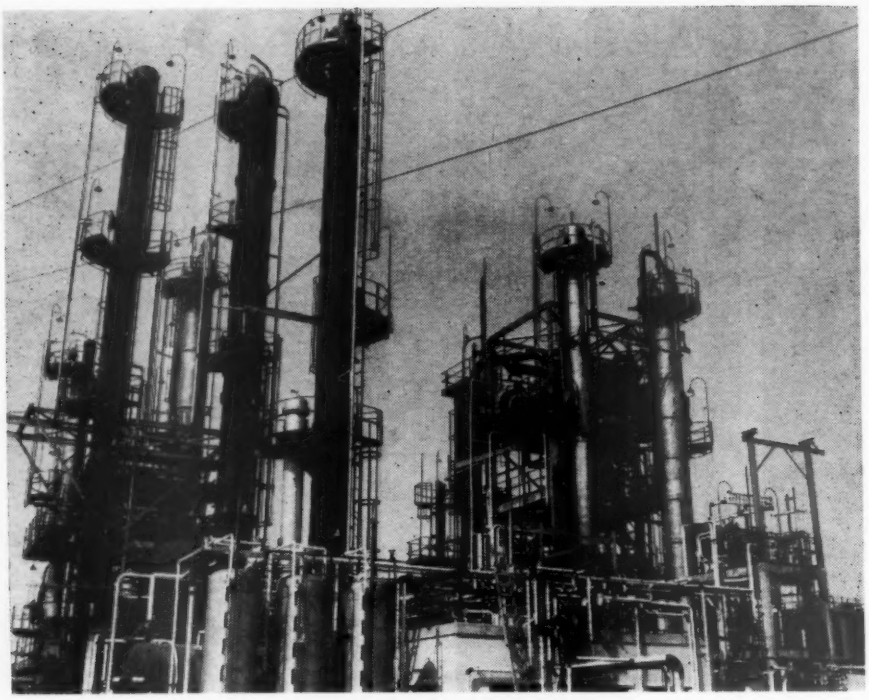
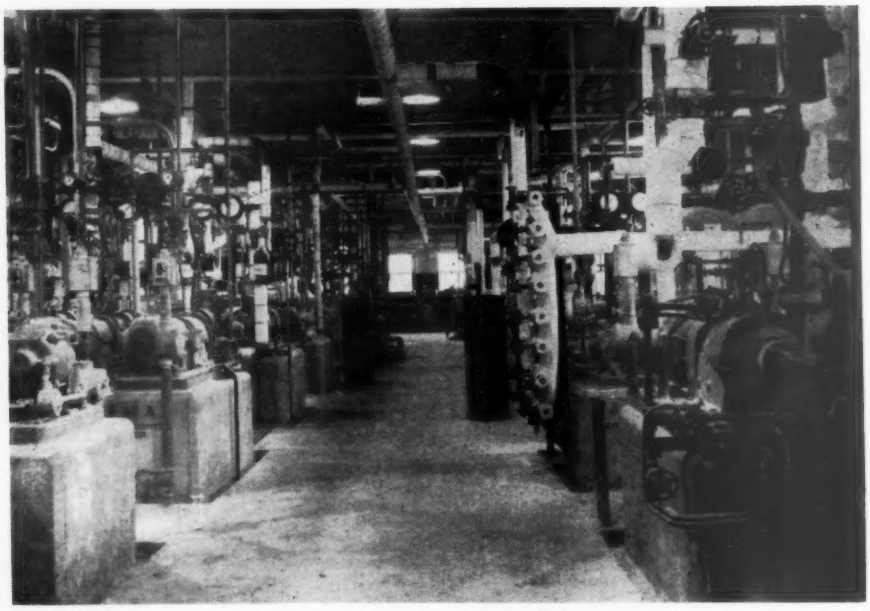


General view of pump house and fractionating towers.



Interior of pump house, situated inside "forest" of fractionators. About 75 pumps are installed to handle all unit's pumping needs.

the production of acetone from calcium carbide, Shawinigan Chemicals producing at Shawinigan Falls virtually all of the Canadian output. Now, however, the new cumene process has made it advantageous for Shawinigan to join in the petro-chemical production and divert the calcium carbide to other uses.

"The plant of the new entity, representing an investment of more than $4,000,000, is situated near the British American Oil Company Ltd. Montreal East refinery, on Sherbrooke Street, the chief motor-traffic thoroughfare of the Canadian metropolis and seaport. The initial unit is one for the manufacture of phenol and acetone from cumene by a newly developed process, which was worked out independently and simultaneously in Britain and in the United States.

"In the United Kingdom the work was done by the Distiller's Corporation, Edinburgh and in the United States by the Hercules Powder Company, of Wilmington, Delaware. Both of those companies have protected their inventions by various patents and patent applications.

Stems from New Refinery Installations

Initial processing of the B. A.-Shawinigan Ltd. production line stems from the new and enlarged installations of the adjacent British American Oil Company Limited refinery. Those, coupled with post-war advances in modern technology, have resulted in the development of the basic cumene in a state of exceptional uniformity and quality.

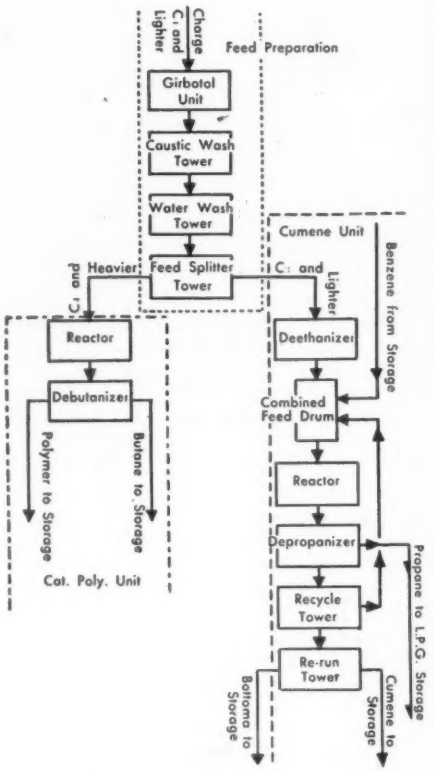
Said J. Willis Morgan, manager of the Montreal East refinery, describing the process in detail:

"The British American cumene unit is adapted to its existing catalytic polymerization installation. The unit, as it now operates, consists of a feed preparation unit, the cumene unit and a catalyst polymerization unit. Liquid refinery gases consisting of butane and lighter are charged to a Girbotol unit. The hydrocarbon stream is freed of hydrogen sulfide and is passed through a caustic wash to remove any additional sulfurs, such as mercaptane. After the caustic wash the feed is water-washed, to remove traces of caustic and nitrogenous compounds which might affect catalyst life adversely.

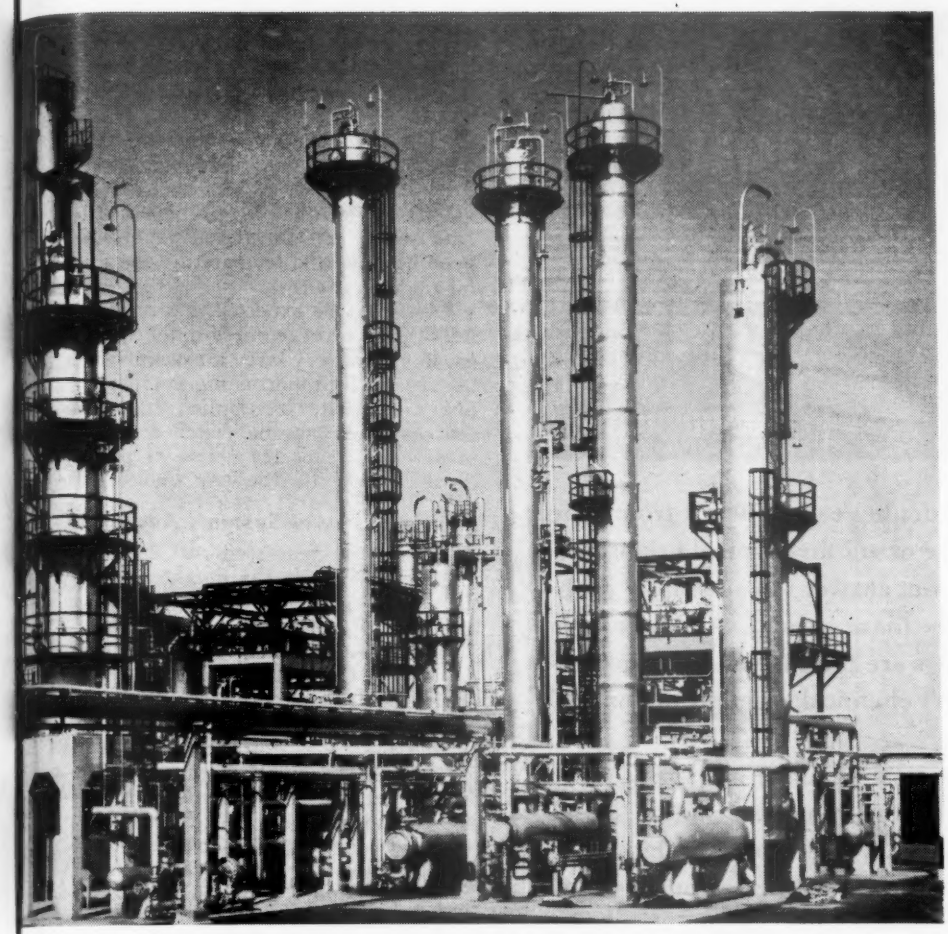
"The feed leaves the water-wash tower and is charged to feed splitter, which splits the sulfur-free feed into an overhead stream consisting of C_3 and lighter and a bottoms stream consisting of C_4 and heavier hydrocarbons. The C_3 and lighter stream is charged to the cumene unit and the C_4 and heavier stream to the UOP catalytic polymerization unit.

Almost 100 Per Cent Propylene-Cumene Conversion

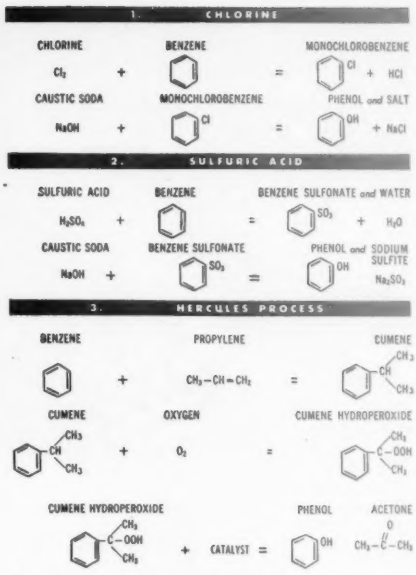
"The C_3 and lighter fraction is charged to the de-ethanizer, which sepa-



Flow diagram, showing interconnections between feed preparation units, cumene plant and catalytic polymerization unit.



Cumene plant, Montreal East refinery of British-American Oil Company, Limited, which supplies charge stock for phenol-acetone unit nearby.



Chemical reactions involved in the synthesis of phenol by three processes.

rates the C_2 and lighter overhead from a propane-propylene bottoms. The de-ethanized propane-propylene stream continues to the combined feed surge drum, where it is mixed intimately with Benzene make-up from storage and recycle benzene

"The combined feed is pre-heated to 450 F and is charged to a chamber type reactor, which is filled with UOP phosphoric acid catalyst. The benzene to propylene molal ratio of the combined feed must be at a high level and the alkylation of the benzene is effected in the vapor phase. Almost 100 per cent conversion of propylene to cumene is possible. The reactor effluent is charged to a de-propanizer.

"A de-propanizer overhead stream of propane is sent to LPG storage. The bottoms from the de-propanizer are charged to a recycle tower. Benzene is taken overhead and is charged as recycle to the combined feed drum. The bottoms of the recycle tower are charged to a re-run tower and the high quality cumene is taken off as an overhead product. The bottoms from the re-run tower consist of propylene polymers and diisopropylbenzene and are sent to bottoms storage.

"Butane-butylene stream from the bottom of the feed splitter tower is charged to a cat-poly reactor. The effluent from the reactor is charged to a debutanizer tower. An overhead stream is yielded as butane. The bottoms from the debutanizer go to polymer gasoline storage.

Unit Construction Canadian

"The cumene unit was designed jointly by Universal Oil Products Company and the B-A engineering staff. The unit construction was carried out by W. M. Barnes Construction Company Ltd., Toronto. It is so designed that, at some future date, it could produce propylene tetramer, which is used as foundation for the production of detergent bases.

"The catalyst in both the cumene and the cat-poly reactors is a UOP phosphoric acid type catalyst in pellet form. The benzene used in the cumene operation is not produced in the refinery, but is obtained from the Canadian steel industry and is brought in by lake boats during the summer and by rail tank cars during the winter.

Benzene-Carrying Lines Steam-Traced

"The cumene is pumped directly to B. A.-Shawinigan through a pipe line extending between the two plants. The design capacity of the unit is 600 bbl per stream day of cumene and 185 bbl per stream day of propylene tetramer. The unit is completely instrumented with conventional petroleum refinery type pneumatic and electronic instruments. All lines carrying benzene are steam-traced and insulated—a precaution necessitated by the high freezing point of benzene (42 F)."

Discussing the ensuing processes in the B. A.-Shawinigan plant, Dr. Jane stated that the oxidation of cumene to cumene hydroperoxide and, particularly, cleavage of the hydroperoxide with 10 per cent aqueous sulfuric acid to phenol and acetone, were studied by Hock and Lang in Germany, as reported in the German chemical literature in 1944. The oxidation of cumene, as carried out by these workers, was relatively slow and gave low yields of the hydroperoxide; the cleavage of the hydroperoxide gave low yields of phenol. These reactions also were studied in the United States by the Hercules Powder Company and in Britain by the Distillers' Company, Ltd. The latter studies led to the development of a commercially attractive process which gives good reaction rates and high yields of phenol and acetone.

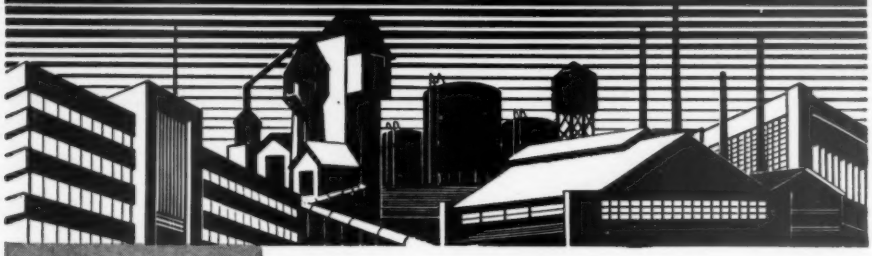
"Cumene may be oxidized either with pure oxygen or oxygen from the air and the conditions of manufacture as to temperature and pressure are those which have been determined by a great deal of development work to be most economical," the B. A.-Shawinigan expert observed.

Highest Chemical Efficiency Sought

"The oxidation carried out by this company takes place in vessels under appropriate conditions, with the introduction of adequate air at moderate temperatures. The degree and method of conversion are selected to obtain the highest chemical efficiency and the minimum formation of undesirable products.

"Since there are a number of products formed in the process, a suitably designed fractionation system is required to produce phenol and acetone of suitable purity to meet the highest market standards. Several other products are

we put the "Automatic" in FIRE PROTECTION



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You've no doubt read or heard from time to time that one or another type of fire protection is the correct answer to your safety problem. One says foam is best. Another says water sprinklers are the answer. Perhaps carbon dioxide, dry chemical, or other media will do the trick.

What is the most effective method?

Without a thorough understanding of all conditions involved, we wouldn't hazard a guess. For fire protection, like any other scientific problem, requires (1) technical know-how, and (2) application of that knowledge. Most methods of fire safety are good . . . but only through "FIRE PROTECTION ENGINEERING"—designing, manufacturing and installing the specific type of system *best by test*—can you be sure of maximum safety.

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produced in lesser quantities and those are purified to produce commercial quality products, including alpha methyl styrene, acetophenone, and mesityl oxide.

"The fractionation section requires a number of fractionating columns, varying in height from 50 ft to about 100 ft.

"The purification section is heated by both steam and Dowtherm vapors, depending upon the temperature required for the operation.

"As might be expected, a large number of pumps are required in the system, varying from very large air compressors to very small proportioning pumps. The plant electricity is supplied from two sources which may be switched rapidly to provide a constant source of power, in case of electrical system failure."

Auxiliary Power Systems Available

"Steam is generated in duplicate units, one of which can operate without the use of electrical power, to insure heat supply in case of current failure.

"Although situated adjacent to one of the largest flows of fresh water in the world, the St. Lawrence River, the plant conserves cooling water by the use of cooling towers. A few hundred gallons per minute of make-up provide sufficient water for all plant requirements. The cooling towers are of forced draft type and occupy only a small space to provide a capacity of several thousand gallons per minute of process water.

"The air requirements are supplied by several types of compressors, depending upon the necessary service and those are situated in several appropriate parts of the plant.

"Drainage for the system goes to a central trap which is constantly checked to maintain an effluent which has only a very minute proportion of any of products produced by the plant." * * *

Carter Builds Poly Unit

A new polymerization unit at The Carter Oil Company's Refinery, Billings, Montana, which will increase the high octane gasoline production of the plant 27,000 gal daily, has been placed in operation, I. J. Staid, manager of manufacturing, announced.

The new unit, under construction 19 months, consists of 4 towers, ranging in height from 26 to 70 ft and from 3 to 4½ ft in diameter. Gases that are a byproduct of regular refinery operation are processed in these towers.

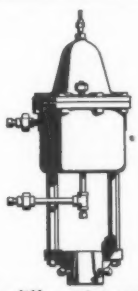
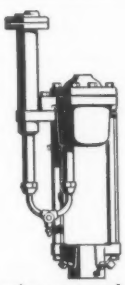
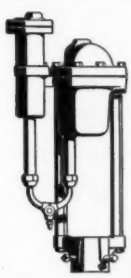
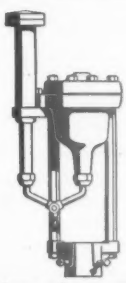
Carter has spent in excess of $350,000 in equipment to convert these gases, formerly unused, into high grade gasolines. With this additional production from the polymerization unit, the average gasoline output will exceed 360,000 gal daily, Staid said.

The new Carter refinery, completed and placed in operation in 1949, processes an average of 21,000 bbl of crude daily.

XUM

What's worth metering is worth metering right!

. . . and Foxboro offers the *right* meter for any metering problem. Round and rectangular cases. See the varied types below.

TYPE 22 Meter Body	TYPE 29	TYPE 27 Meter Body	TYPE 28 Meter Body	TYPE 26 Meter Body
				
light weight and low cost, preferred for portable recording, or with 6" indicator, for mounting directly on piping.	for differential ranges as low as 1" H_2O, especially for low pressure gas and air service.	superior general use meter with all Foxboro design features for high sustained accuracy and maintenance-freedom.	longer float travel, greater power, highest accuracy meter ever built.	leakproof measurement at really *high* pressures without compromise in accuracy.

a flow meter type for every need

From its complete line of flow meters, Foxboro can offer the *best* type — in the proper range and static pressure rating — for virtually any metering problem. They are available as indicators, recorders, controllers, and transmitters — with or without integrator. Foxboro also is the maker of the d/p Cell — the compact force-balance type flow transmitter which uses no mercury.

The widest selection of flow instruments is only one of the many factors responsible for Foxboro's acknowledged leadership in flow metering. See how this factor — together with many superior, exclusive design features — give you the most value for your money. Write for Bulletin 460 on mercury meters, Bulletin 420-1 in d/p Cells.

Specifications of Foxboro Meter Types Illustrated

TYPE	MATERIAL	MAX. W. P.	RANGES
22	Forged Steel	2000	20"—200"
29	Cast Iron	150	1" —10"
27*	Forged Steel	2000	10"—400"
28	Forged Steel	2000	50"—400"
26	Forged Steel	5000	100"—400"
d/p Cell	316 S.S.	750-4000	25"—800"

*Type 27U is a uniform flow scale meter used for steam and other service where demand fluctuates widely. 100" range. Max. W. P. 2000 psi.

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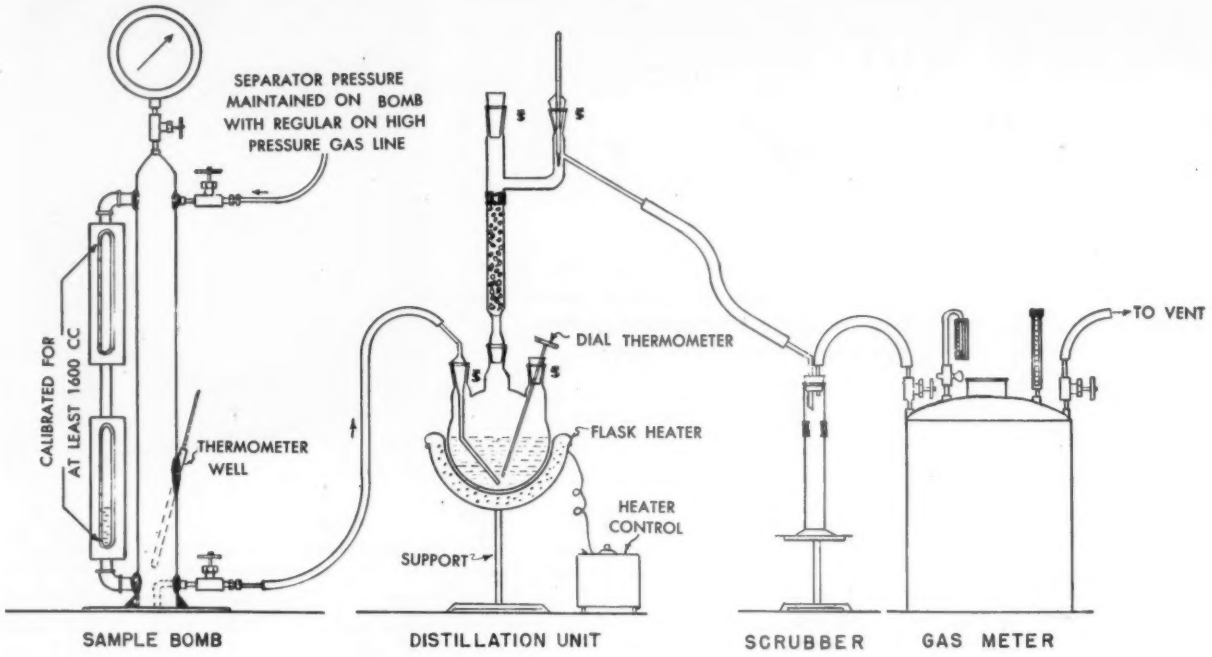
FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND



TEST FOR DETERMINING percentage of stable crude and tank vapors in metered separator crude.

Continental's Tests for Determination of Per Cent Stable Oil and Tank Vapors Volume in Separator Oil

Unique dehydration, liquid phase measurement, and calculating procedures solve important problem

C. T. ARDOIN[1] and C. E. LAMB[2]

A HIGHLY feasible method for handling the products from small scattered gas distillate fields is to utilize one pipe line to carry both the separator liquids and gases from the scattered fields to a central plant where the commingled liquids are stabilized and the liquefiable contents of the separator gases and tank vapors are extracted.

Continental Oil Company has utilized this method in Southern Louisiana for several years. In this operation, a central separator battery and dehydration plant are installed at each field. The separator liquid produced from each lease is metered under separator pressure and filtered through a hay tank to remove free water. The separator gas from each lease is metered and dehydrated. The two phases then are combined for transfer to the centrally-located combination oil stabilization and gasoline plant.

Dehydration problems involved in this method are not unique, but the measurement problems for the liquid phase are unique. We have devised a method for calculating a breakdown of the metered volume of separator oil into the equivalent volumes of stable oil and stock tank vapors which represent the oil which would be accumulated in stock tanks and the flash vapor that would be vented to atmosphere under normal production procedure. This method consists of a combination of two flash tests, one conducted in the field and one in the laboratory.

Field Flash Test

Equilibrium separator oil is metered and flashed into a 100-bbl atmospheric test tank to determine the ratio of stable oil to equilibrium oil. Approximately 10 bbl of stable oil are collected for each test. This test is conducted once each month for each lease separator and the factor obtained is applied to the meter reading to convert volume of equilibrium oil to an equivalent volume of stable oil. Immediately following the flash test, a sample of equilibrium oil is taken for laboratory testing.

Laboratory Flash Test

1. **Apparatus.** The apparatus used consists of a sample bomb, distillation unit, scrubber, gas meter, Reid vapor pressure bomb, 2000 ml graduated cylinder, and suitable hydrometer.

(a) *Sample bomb.* The sample bomb, illustrated in accompanying sketch, which is used both for sampling from the separator and charging into the distillation unit, is fabricated from a length of 2½-in. ID seamless tubing; two high pressure reflex gages; three ¼-in. high pressure needle valves, and necessary ells and tubing. This apparatus is designed to have a minimum calibrated

[1] Chemist-in-Charge, Basile, Louisiana.
[2] Process engineer, Lafayette, Louisiana.

EXCLUSIVE

volume of 1600 ml within the sight gage range.

(b) *Distillation Unit.* The distillation unit consists of a 2000 ml, pyrex round bottom flask with 3-neck T/S 24/40 joints; pyrex glass charging tube with male T/S 24/40 joint; stopper with zero to 180 F dial thermometer inserted, and distilling tube with glass bead packing and side arm adapted for thermometer insertion in the overhead vapor delivery flow. Auxiliary equipment for the distillation unit proper consists of a mantle-type hemispherical heater for the 2000 ml flask; a variable transformer; and an easily portable ice bath that may be used in place of the heater if required.

(c) *Gas Meter.* A charcoal test meter with thermometer and mercury manometer is used.

(d) *Vapor Pressure Bomb.* The immersion-type Reid vapor pressure bomb complete with zero to 15 psig range test gage is used to determine vapor pressure of the stable "bottoms."

(e) *Liquid Measurement.* A 2000 ml graduated cylinder is used for measuring stable "bottoms."

(f) *Hydrometer.* A four-ounce size API combination hydrometer is used to determine gravity of the stable "bottoms."

2. **Sampling.** Connect top side ¼-in. valve on the sample bomb to gas connection on the separator with copper tubing. Purge bomb thoroughly by first venting gas through the bottom valve, then, applying separator pressure to bomb and venting to atmospheric pressure at least three times. After purging, open gas valve to maintain separator pressure on bomb during sampling. Now, connect copper tubing to oil connection of separator. Connect this tubing to the bottom valve of the sampling bomb using a tee and bleeder valve connection. Flush the connecting tubing with oil, throttling the flow sufficiently to prevent pressure drop in the tubing. The apparatus is now ready for sampling. Open the oil valve and allow oil to gravitate into the bomb. When the oil level reaches the top of the gage glass, close the oil and gas valves. Record separator pressure, temperature of sample, and temperature of oil in test tank determined during field flash test.

3. **Preparation of Apparatus.**

(a) Connect distillation unit scrubber and gas meter as shown in attached sketch.

(b) Take initial meter reading.

(c) Connect sample bomb to a laboratory high pressure gas supply and regulate to maintain separator pressure in bomb throughout the sample charging period.

(d) Connect flexible charging tube to sample bomb and flush well with the oil withdrawn as the level in sample bomb is lowered to the top calibration mark.

(e) Connect flexible charging tube to pyrex glass charging tube.

(f) Connect side arm vapor delivery tube to the scrubber inlet and scrubber outlet to meter inlet with flexible tubing.

4. **Procedure.** Oil charging valve on the sample bomb shall be opened slightly allowing the liquid to be charged into the distillation flask at a rate governed by the quantity of flashed vapors. A back pressure of four ounces is maintained on the system during the charging period by regulating the discharge valve on the gas meter. The temperature determined during the field flash test is the temperature at which the oil in the flask is to be maintained during the charging period. Temperatures of the oil in the sample bomb and vapor through the meter should be recorded at the beginning, during, and at the end of the charging period so the average temperatures may be determined. Charge 1500 ml from the sample bomb, close the charge valve and allow two minutes for state of equilibrium to be reached. Record final meter readings, then, remove the distilling and charging tubes from the distillation flask, closing the flask openings with stoppers. Let the distilling flask reach room temperature. Pour the "bottoms" into the 2000 ml graduated cylinder, allowing the flask to drain well. Record the temperature and volume of the liquid, then, determine the vapor pressure and API gravity.

5. **Interpretation of Results.** A check on the per cent of stable oil determined by the field flash test may be obtained by dividing the volume of distillation "bottoms" corrected to 60 F by the 1500 ml charged volume corrected to 60 F. The volume of flashed vapors corrected to 60 F divided by the volume of sample charged corrected to 60 F and expressed in barrels will represent the equivalent volume of stock tank vapors contained in each metered barrel of separator oil.

A low temperature fractional analysis of the tank vapors may be made to determine the liquefiable hydrocarbon content. * * *

P 219.3

Test for Presence and Evaluation of Product Soluble Rust Inhibitors

P. L. DeVERTER*

WIDESPREAD interest in product-soluble rust inhibitors for protection of pipe line systems and tankers, has developed rapidly in the past few years. There are several basic types of such inhibitors on the market and a quick laboratory test is needed to indicate the presence and effectiveness of such inhibitors. A quantitative test can be developed for a particular type of inhibitor, when known, but would probably require precise technique. A qualitative test to indicate the presence of such inhibitors was developed to assist in our field work on pipe lines. This test can also be used to evaluate and compare the effectiveness of such inhibitors. This test has been used for 18 months and has proved satisfactory.

Proposed test is a modification of ASTM Method D 665-52T, entitled "Rust-Preventing Characteristics of Steam-Turbine Oil in the Presence of Water," published in the ASTM Committee D-2 book. Modifications and rating system suggested are as follows.

Scope. This method of test is used to evaluate the rust inhibiting qualities of product soluble rust inhibitors when added to gasoline or light oils. Water is mixed with the oil during the test.

Nature of Test. The method involves stirring a mixture of inhibited product and distilled water at room temperature with a cylindrical steel rod immersed there-in.

Apparatus. As specified in ASTM Method D 665-52T.

Test Specimen and its Preparation. As specified in ASTM Method D 665-52T. Test specimen shall be made of SAE 1020 steel. See note below.*

Procedure. Pour 350 ml of inhibited product in the beaker. Cover the beaker and insert stirrer and polished rod. Stir for 10 min to insure wetting the rod. Remove 50 ml of the product with a pipette and add 30 ml of distilled water. Continue the stirring for 1 hour at room temperature (72 to 80 F).

Caution: If the sample contains TEL do not fill the pipette by sucking with the mouth. Use a vacuum line or other convenient means.

Stop stirrer, remove steel rod, examine and rate appearance according to the following table:

Appearance of rod	Rating	Designation
Free of rust	passes	R-1
Trace of few spots	passes	R-2
Less than 5 per cent surface rusted—barely passes		R-3
5 to 50 per cent surface rusted—does not pass		R-4
50 to 90 per cent of surface rusted—does not pass		R-5
Surface covered with light rust—does not pass		R-6
Surface covered with heavy rust—does not pass		R-7
A typical report would read—rust test—passes		R-2

*NOTE — Rods sold as SAE 1020 vary in rusting tendency. The rods used in this test should produce a rating of R-7 in Aviation Gasoline which contains no rust inhibitor. Rods prepared from concrete re-inforcing rods, ASTM. A15 specification, give satisfactory results. * * *

*Inspection laboratory, Humble Oil and Refining Company.

NEW MASONEILAN 12000 SERIES

Offer Accurate, Sensitive,

New Ease of Selection;

Proportional Controller

Proportional-Reset Controller

These new controllers reflect a realistic blending of past experience and current design trends, combining advanced features which reduce weight, improve adjustability and increase ease of selection, installation and servicing.

Consider what these design improvements can mean to you . . .

UNIT CONSTRUCTION

Unit subassemblies of the control mechanisms (proportional, or proportional-reset, unit and level setting mechanism) are mounted on the mechanism bracket which is in turn rigidly attached, piloted and doweled to the torque tube housing. Thus, individual units are fixed in position, unaffected by possible distortion of the case, yet are readily removable for servicing or interchange. Other sub-assemblies (pilot and manifold) are mounted in the rugged aluminum case which is finished and gasketed for outdoor service. Cover is closed by a positive cam-type latch.

SIMPLE AIR CIRCUITS

The high-capacity, balanced, amplifying, pilot with frictionless floating-action valve and cleanable sapphire orifice, is connected to the forged brass manifold which contains most air passages. Tubing in the proportional controller is limited to two short lines. The nozzle is easily removable for cleaning, and after replacement requires no aligning. Special ring type adapters facilitate connections.

EASE OF ADJUSTMENT

Proportional band setting . . . is made on a rod-type cantilever spring by a self-aligning clamp tightened by a large knurled knob located in front of the mechanism. A four-inch direct reading scale indicates the setting.

Control action and specific gravity setting . . . are selected by attaching the control link to desired side of reversing arc along the specific gravity scale, graduated from 0.5 to 1.4. The arc is easily reversible when instrument mounting is changed to opposite side of displacer.

Set point . . . is precisely adjustable throughout entire range by turning setting knob over 270° arc scale, 2″ long. Scale is reversible when control action is changed.

Direct level indication . . . is provided by a sturdy pointer fastened directly to the torque tube rod. The scale is graduated for both left and right hand instrument mounting and for several specific gravities.

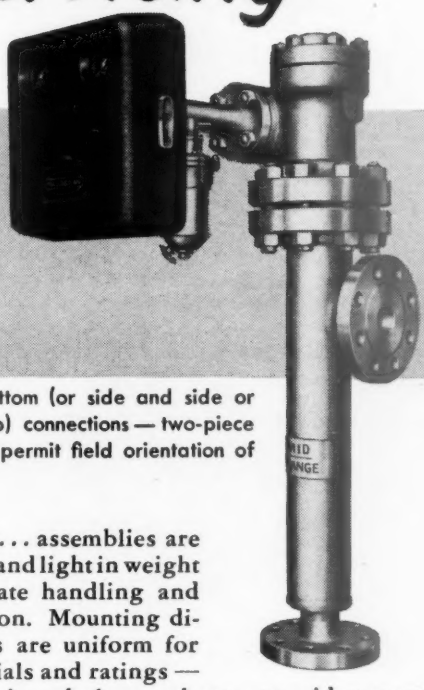
FOR A WIDE VARIETY OF APPLICATIONS

LIQUID LEVEL CONTROLLERS . . .

Dependable Control – plus

Adjustment and Servicing

Top and bottom connections — integral chamber



Side and bottom (or side and side or side and top) connections — two-piece chamber (to permit field orientation of instrument)

Alignment micrometer . . . is sturdily mounted, is readily accessible and permits adjustments with minimum disturbance.

VERSATILITY

The proportional controller . . . may be used as a *Transmitter* and can be converted in the field to a

Differential gap controller . . . by simply reversing position of the coil spring and bellows in the proportional unit; or

Proportional-reset controller . . . by interchanging the proportional unit and the proportional-reset unit.

STURDY, COMPACT, ACCURATE MEASURING UNIT

All parts of the *Torque Tube Assembly* are made of a single alloy, individual parts being welded to form an integral unit. Knife-edge bearings support both ends of torque tube. Torque tube housing is removable from mechanism chamber.

Stainless . . . steel tubing *Displacers* designed so that standard control mechanism can be used for all ranges, are attached to the torque arm by hangers with modified-knife-edge hooks. Hanger extensions may be integral or detachable.

Chamber . . . assemblies are compact and light in weight to facilitate handling and installation. Mounting dimensions are uniform for all materials and ratings — and are in whole numbers; on side-mounted types mounting dimensions equal level range.

VARIETY OF TYPES, MOUNTINGS, MATERIALS

Instrument Types include *Proportional, Proportional-reset, Differential Gap Controllers* and *Transmitters;* or any combination of two of these in larger case. *Mounting Types* include top and bottom, side and side or side and either top or bottom, with screwed or flanged connections; also top or side of vessel with flanged connections. Instrument mounting left or right of displacer.

Ratings up to 2500 lbs. ASA.

Materials include iron (14″ & 32″ only), steel or alloy chambers; stainless steel displacers; inconel (or wide selection of other materials) torque tube assemblies.

Ranges — 14″, 32″, 48″, 60″, 72″, 84″, 96″, 120″

Complete details sent on request. Address

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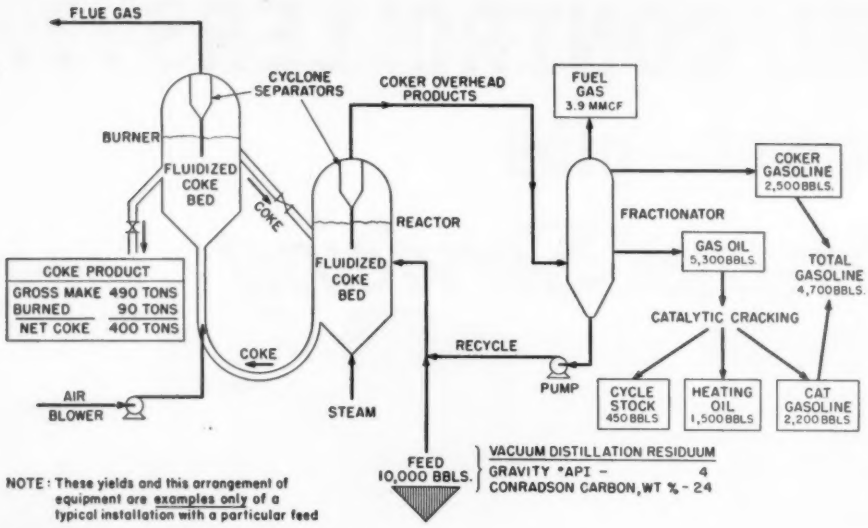
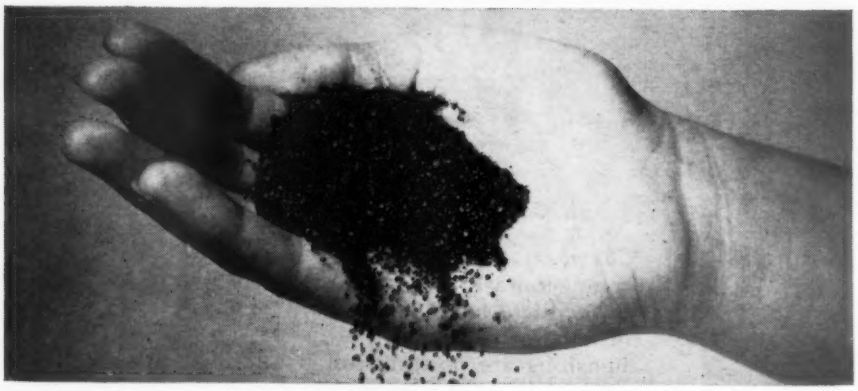
IN THE PROCESS INDUSTRIES



SIMPLIFIED flowchart of fluid coking process.



GRANULAR coke produced in the new fluid process, is suitable for practically all uses to which petroleum coke can be put.

New "Fluid Coking" Process Boosts Domestic Fuel Yields From Residual Oils

Conversion of heavy fuel oil to salable products solves one critical refiners' problem

ARCH L. FOSTER*

ANNOUNCEMENT of the new "Fluid Coking" process for the conversion of heavy residuums to motor fuel, heating oil, coke, and gas is the most recent answer to the problem of economical disposal of these heavy ends of crude. The new process has been under development for four years by Standard Oil Development Company, research subsidiary of Standard of New Jersey interests, with the main portion of the work being carried out in a 100-bbl per day plant at Esso's Baton Rouge, Louisiana, refinery.

The process is the latest development of the fluidized solids principle of operation, first made famous by the fluid catalytic cracking process, that came to the fore, and the rescue of the Western World in the early stages of World War II. Although not too profuse details of the operation are available, it is claimed by its progenitors that the process can mean reduction of crude requirements in the industry by 800,000 bbl per annum, said E. V. Murphree, head of Standard Oil Development Company. Conversion of railroad locomotives from the conventional steam, generated by heavy fuel oil, to the diesel-electric type of motive power fuel by diesel (distillate) oil has placed the refiner in a "pocket" from which disposal of heavy cracked and other residues is a critical quandary indeed in recent years. Increase in demand for heavy residual fuels has been only 2½ per cent annually, it was reported, whereas distillate heating oils and gasoline are being consumed at 8 per cent increase rates per year.

*Editor, Refining and Petrochemical.

EXCLUSIVE

Evidence of the confidence held in this new process is given by the fact that three new units are in the planning and designing stages. One, for 3000 bbl per day, is for Carter Oil Company, Standard affiliate, at Billings, Montana, to be operating by the end of 1954. Two others, for 10,000 bbl per day and 20,000 bbl per day respectively, are to be built at Esso's refineries at Baltimore and Baton Rouge. The process is open to license by the industry "at reasonable royalty rates," it was announced.

By the new process a 10,000 bbl charge of heavy residuum may be converted into the following yields of more salable products:

Coker gasoline	2500 bbl
Gas oil	5300 bbl
Coke	490 tons

When the gas oil is processed in a catalytic cracker the yields are:

Catalytic cracked gasoline	2200 bbl
Cycle stock	450 bbl
Heating oil	1500 bbl

During the process 90 tons of the coke may be burned as process fuel, or, natural or refinery gas may be burned.

Coke Circulated as Heat Medium

In a manner similar to the fluid cracking process, coke, formed in the process, is heated in a "burner" in which a portion—about 20 per cent—is burned to heat the coke mass. This hot mass, in small granules, is circulated to the reactor where it comes into contact with the charge, the hot coke being in "fluidized bed" form as is the catalyst in a fluid cat cracker unit reactor. Temperature in the reactor is maintained at 950-1050 F as a typical range.

In the reactor the charge is decomposed into either overhead vapors or into coke, which latter is deposited on the coke already in the bed. A continuous stream of the coke is withdrawn and sent to the burner to be reheated and to maintain the temperature of the reactor bed. Surplus coke is withdrawn also from the burner, for any purpose for which coke may be employed, in cola-coke burning furnaces, domestic fuel, etc. Coke from some stocks is said to be most valuable for making carbon electrodes for electric furnaces and similar uses.

Not only may heavy residues be refined in this process to make more valuable products in greater demand, say those responsible for its development, but gone is the need for blending 40-60 per cent of distillate oils needed to fluidize the heavy residual oils from vacuum and thermal cracking stills, etc., which blending oils can be employed as additional yield of distillate fuel oils of greater value. * * *

ADEN REFINERY site, from Administration Hill. No. 1 topping unit foundations in foreground; background shows towers of sulfur dioxide extraction unit.

Largest British Refinery Building Rapidly

Foundations, docks, workman "cities" building for 100,000 bbl per day plant at Aden, Arabian "Hot Spot"

A. E. C. DRAKE*

After eight months' preliminary work on Anglo-Iranian Oil Company's 100,000 bbl a day refinery, being built at Aden, Arabia, emphasis has swung from site and camp preparation to refinery erection. By mid-June the first eight towers and vessels for the SO_2 extraction plant were in position, this being the first refinery plant erected. Over a million cubic yards of sand had been dredged from the harbor; 335,000 cu yd of rock, one third of the total required, had been placed in position in the parmanent harbor works, and a 700 ft long pontoon bridge had been laid across the Khor Bir Ahmed, a narrow strip of water between the refinery site and Aden town.

On the other side of the register the southwest monsoon broke on Aden on June 16, a month earlier than usual bringing with it strong winds which make working conditions until September particularly trying. July 7 was the hottest, most humid in Aden's memory of the last 40 years, the thermometer registering 104 deg with a relative humidity of 73 per cent.

Early in June the first pile for the first of four tanker jetties was driven, marking the beginning of a new stage in the harbor project. Over 5,000,000 cu yd of sand are to be dredged to provide a suitable basin with a turning circle and approach channel for the biggest tankers afloat. Dredged sand is being pumped on the foreshore to form a reclaimed area for the port oil storage tanks and administrative buildings. This area is being enclosed by rock bunds.

Work on the site of Aden refinery, which is the biggest now being built in the British Commonwealth, began on November 1, 1952. After much preliminary work the pouring of foundations for major refinery plant began in June this year. In addition to the work on the SO_2 units, concrete foundations are being poured for one of the two topping units, and the laying of underground piping has started. Excavation work for the foundations of other refinery plant is well advanced.

When the refinery is completed at the end of 1954 in addition to the two topping units, each with a capacity of 60,000 BSD, there will be a Platformer with a capacity of 12,000 BSD, an SO_2 extraction plant with a capacity of 8800 BSD and an Autofiner capable of handling 3500 BSD, as well as miscellaneous sweetening plants.

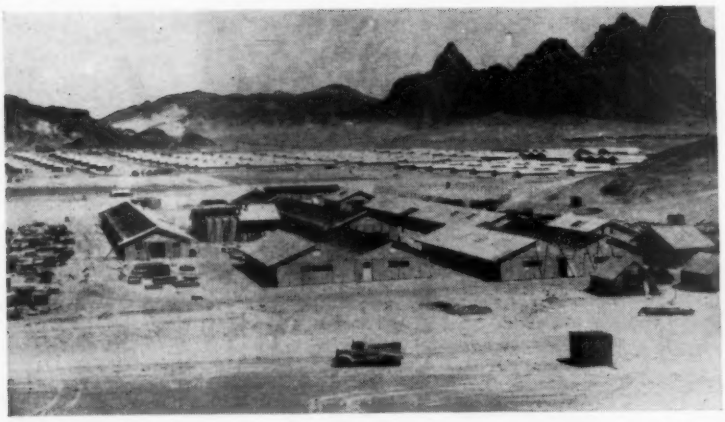
80,000 Tons of Equipment in 9 Months

In the nine months from November 1952 to July 1953 nearly 80,000 tons of equipment and materials poured into Aden from the United Kingdom, Europe and America. These shipments were for both the refinery and harbor projects and were off-loaded in Aden harbor on to barges for the trip across the bay to Little Aden, site of the refinery. This terrific tonnage has created a great deal of extra stevedoring work but in no way has it disrupted the services of Aden port.

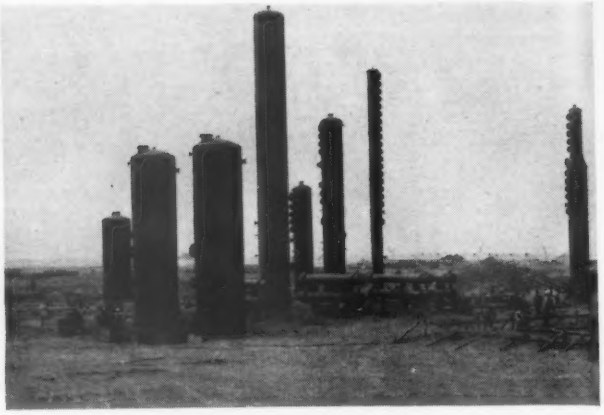
Aden harbor authorities have co-operated fully with the contractors, Middle East Bechtel Corporation, and George Wimpey and Company. When a load of steel pipes accidentally slipped into deep water in the harbor the authorities were only too willing to lend underwater detection gear and the piping was located and raised quickly with the assistance of local divers.

As equipment has flooded in, men

*Anglo-Iranian Oil Company.



HOSPITAL, foreground, will have 150 beds, operating "theater," X-ray and dental units. Background is camp for 1500 American and European workmen.



SO_2 EXTRACTION unit towers, first plant unit to be built, will treat 360,000 tons (2,500,000 bbl) of kerosine annually.

TYPICAL of Eastern construction crews, these Arab laborers are drilling into "Wedge Hill" rock face, preparatory to setting off dislodging blasts.

and machines have worked steadily grading the refinery site. Huge volcanic growths have been almost levelled, one large quarrying operation began on July 6 when a rocky feature between the refinery site and the port area, known as Wedge Hill, was blasted with 34 tons of explosive. Over 100,000 tons of rock were dislodged and large blocks will be used in the armouring of the breakwater being constructed to protect shipping against the storms of the monsoon season.

Plant to Cost $112-$140 Million

During the building of the refinery, which will cost between £40 million and £50 million ($112-$140,000,000), approximately 100,000 tons of steel will be used in the plant, storage tanks and jetties. Over 20,000 tons of cement will be required to mix the 180,000 cu yd of concrete which will go into the construction of the refinery and port. Several million board feet of timber for concrete shuttering is being imported.

Contractors' construction plant is valued at £3,500,000 ($9,800,000) and to use all the mechanical equpiment an army of workmen is being recruited. About 10,000 men, including British, Americans, Dutch, Italians, Indians, Pakistanis, Somalis and local labor, are at present employed on site. At the peak period, about the end of this year, more than 14,000 men will be working on the refinery and harbor, and nearly 1000 tons of food will be imported each month to feed them.

10,000 Men on Job

One of the first tasks on the site was the building of construction camps, each a temporary townlet complete with its own living quarters, mess, recreation center, and other facilities. These camps are being expanded as the labor force grows. In addition to accommodation buildings, stores, workshops, a temporary hospital, and a garage were all erected and operating within four months of the start of work. More recently electrical, welding, carpentry and plumbing shops, power plant, cold storage plant, laundry, bakery, rock crusher and concrete batching plant and an administration building were completed.

To provide the 500,000 gal of water needed daily for domestic purposes in the construction camps, a number of wells have been drilled at Bir Ahmed, about 10 miles from site. Electric pumps raise the water from a depth of 90 ft. After chlorination the water is piped through a 6 in. line to the refinery site where a treating plant and four storage tanks have been built. Later more wells will be drilled and a 12-in. pipe line will provide water at the rate of about 2,000,000 gal a day for domestic and process requirements in both the refinery and harbor areas.

At the harbor site, a short distance from the refinery, a million cubic yards of rock must be placed in position to provide a 4000 ft long breakwater and a bund 9000 ft long. One third of the rock required has now been tipped into the sea. A continuous stream of dump trucks operate between the nearby quarries and the harbor works. The breakwater is now 2700 ft long. Both the breakwater and the bund will be armoured with blocks of rock up to 8 tons in weight and a concrete wave wall will be built on top of the breakwater.

Docks for Largest Tankers

The tanker jetties will comprise one two-berth finger jetty, for which piling is now being driven, and two one-berth T-head jetties. At the roots of the jetties, galleys and smoke rooms are to be built for the use of ships' crews. When the refinery is commissioned two tugs, one fitted as a fire float, will handle shipping, and several company launches and a dredger will be based at the harbor.

Government development work planned for Little Aden peninsula includes a permanent road bridge over the Khor Bir Ahmed. As mentioned previously a 700-ft long temporary pontoon bridge, has already been opened, thus reducing the road distance between the refinery site and Aden town from 25 to 20 miles. The mid-section of the pontoon bridge opens to allow marine traffic to proceed to the nearby salt works.

The traveling time by road from Little Aden to Aden will be reduced still further by a causeway to be built across the Aden Inner Harbor. The road on this causeway will by-pass Khormaksar airfield where at present road traffic is brought to a halt whenever planes are taking off or landing. * * *

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TECHNICAL FORUM

Thixotropy in Greases

Q What is the principle, or property of Thixotropy, and how, if at all, may it be utilized in the manufacture of greases or other lubricants?
W. T. L.

A According to Hotten and Farrington[2] "Thixotropy in lubricating greases is that property which is manifested by a decrease in consistency as a result of shearing, followed by an increase in consistency starting immediately after the shearing is stopped."

This characteristic is common to practically all lubricating greases but such products vary widely both in the extent to which they soften with shear and the extent to which they recover consistency. Naturally, this property is more evident in stiff lubricants than in those of less body.

The rigidity of a soap-oil system is conceded to be due to soap fibers. Therefore, any shear softening may be due to a change in either the arrangement or size of such thickener elements. Fibers in lubricating greases have been examined, by means of an electron microscope, before and after the lubricant was subjected to shear. In most cases, the soap fibers consited of shorter fragments after being worked than before. Brown *et al*[1] were able to point out abrupt fracture edges at the ends of fibers after a lubricant had seen service in a roller bearing. Examples have also been cited in which soap fibers split lengthwise rather than crosswise under shear. Another suggested change in soap fibers, when worked, is that such thickener elements become oriented. Still another possible change is in the forces by which the fibers are attracted to each other both at the points of contact and through the intermediate fluid.

Although reference has only been made to soap thickeners, certain nonsoap thickeners immobilize lubricating fluids in much the same manner as do the soaps. As such systems also exhibit thixotropy, the change in the thickener aggregates may be similar to that just described.

Thixotropy of lubricating greases is of considerable practical importance. When in service in bearings, a certain amount of softening may aid in feeding lubricant to the rotating members. On the other hand too great a shear softening may render a lubricating grease so soft that it will not stay in place. Such has been the experience with some wheel bearing lubricants that softened so much that they leaked onto brake bands.

If after a lubricating grease is forced from the area of service it regains part of its body, it will act as a seal and prevent entrance of dirt or discharge of other softened lubricant. Excessive stiffening, either in service or in storage, however, is not desirable and may be a nuisance. During periods when machinery is idle, some lubricants become so stiff that when motion starts again either channeling results or an excessive torque is developed. Under similar conditions, a lubricating grease in a container may become so stiff it will not feed to dispensing equipment.

Since age-stiffening is sometimes accelerated by high temperatures, lubricating grease should not be packaged at temperatures above 180 F and preferably at considerably lower heats. Hotten and Farrington[2] found no general relationship between the type of soap and age-stiffening. Various structure modifiers should aid in decreasing age-hardening but such additives will probably be specific for different soap-oil combinations.

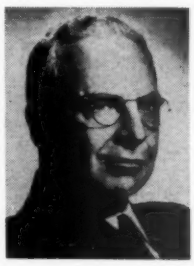
Among the lubricating greases examined by the above investigators,[2] hydrated calcium soap greases had the lowest shear-softening rates and lithium and sodium soap greases the highest. In order to decrease softening during service many manufacturers of lubricating greases subject some of their products to milling during processing. As such milling is frequently quite drastic, further shear-softening in bearings is at a minimum.

The thixotropic behavior of lubricating greases can be determined by use of the ASTM grease worker. Hotten and Farrington[2] suggest a working period of 3000 strokes after which the ASTM penetration is taken. The difference between a value obtained after 60 strokes and that obtained after 3000 gives a measure of the shear-softening.

CJB and RRM

1. Brown, John A., Hudson, Charles N. and Loring, Lewis D., *Inst. Spokesman* 15, No. 11, 8 (1952).
1. Hotten, B. D. and Farrington, B. B., *ASTM Bulletin* 189, 53 (1953).

V. A. KALICHEVSKY JOINS FORUM PANEL



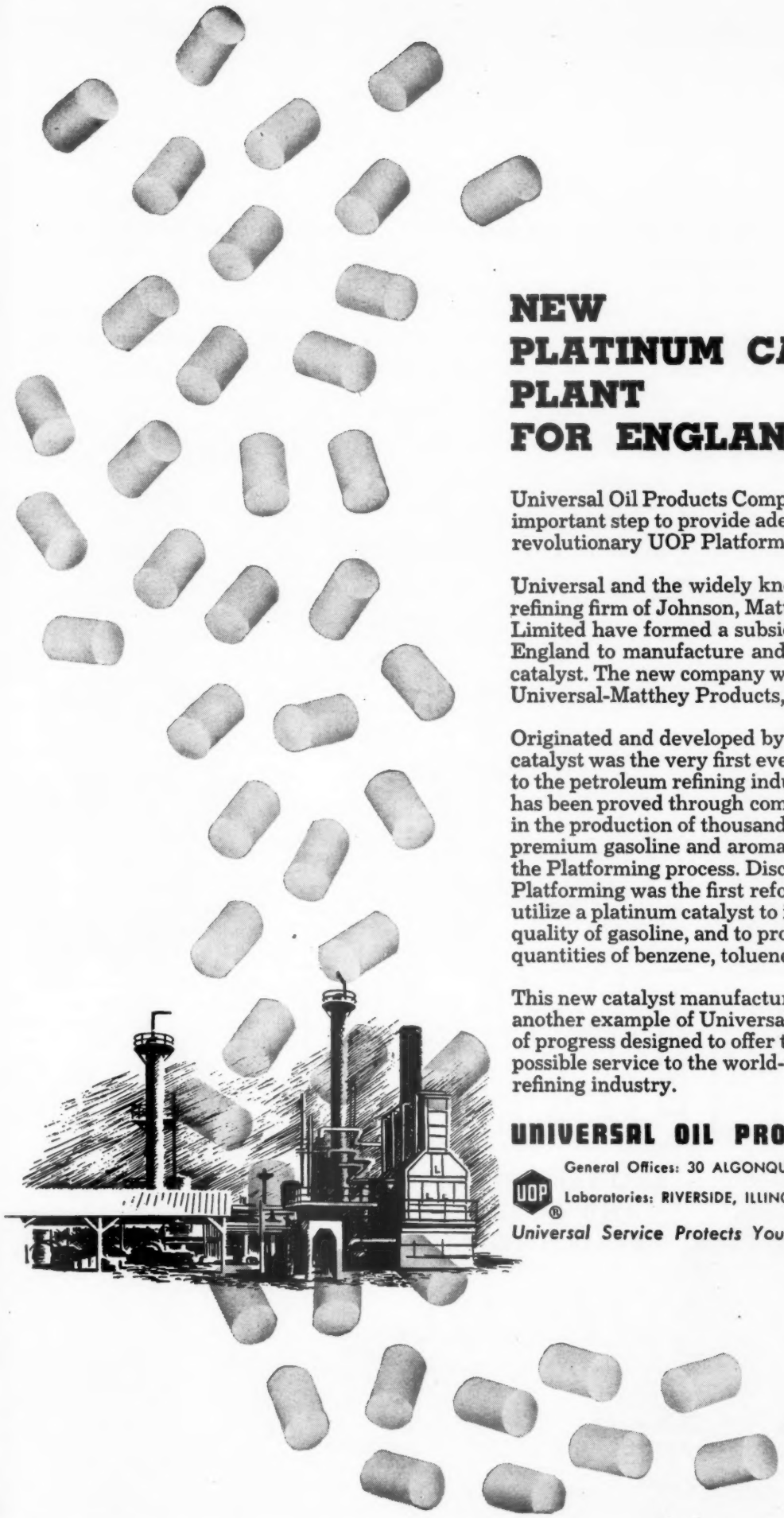
Few people in the petroleum—or any other—industry have had as eventful life as has Dr. V. A. Kalichevsky, "Kali" to his multitude of friends throughout petroleum refining circles here and abroad. Born in Russia where he had a six-year military and diplomatic career just prior to the Communistic revolution, he came later to this country and entered California Institute of Technology, from which he received the doctorate degree in chemical engineering, in 1924. "Kali" went into refining research, development, and plant work with Union Oil Company of California, studying of course West Coast crudes. In 1929 he joined Standard Development in similar work, to transfer to Socony-Vacuum Oil Company two years later.

As time passed he was promoted until he became general supervisor of Socony's research and development department. By 1944 Magnolia, huge Gulf Coast Socony-Vacuum affiliate, needed a consulting chemical engineer to care for its growing technological needs and Dr. Kalichevsky received the nod, transferring to Beaumont as headquarters where he has remained. One major assignment there was the design, construction and placing in operation Process Control laboratories for Magnolia.

During this extended period he was busy with writing a large number of articles and several books. Also he was involved in the development of a number of refining processes for motor fuels, kerosine, and lubricating oils, along with by-product petrochemical products and processes, developed by him or under his supervision. To date he has completed four books on the oil and refining industry, and it is through these that he is more widely known in the industry than even his wide personal acquaintance makes possible. These books are "Modern Methods of Refining Lubricating Oils," "The Amazing Petroleum Industry," "From Oil Well to Engine," and "Chemical Refining of Petroleum," the last co-authored with B. A. Stagner, consulting engineer. At present he is writing in collaboration with Dr. Kenneth A. Kobe, University of Texas, a new book, "Petroleum Refining Agents." In addition to his earlier books he has written some 60 articles, on all phases of refining, and about a score of patents have been issued to him in this and allied fields.

He is quite active in various technical societies, being a member of the American Institute of Chemical Engineers, the American Chemical Society, American Association for the Advancement of Science, American Petroleum Institute, and the Texas Academy of Science. Among his decorations is included the French Medaille de Sauvetage.

Dr. Kalichevsky will prepare answers to a wide variety of questions in the field of petroleum and petrochemical processing. The Technical Forum is most fortunate in being able to add him to its Panel.



NEW PLATINUM CATALYST PLANT FOR ENGLAND

Universal Oil Products Company has taken an important step to provide adequate quantities of the revolutionary UOP Platforming catalyst in sterling.

Universal and the widely known platinum refining firm of Johnson, Matthey & Company, Limited have formed a subsidiary in England to manufacture and market platinum catalyst. The new company will be known as Universal-Matthey Products, Limited.

Originated and developed by Universal, this platinum catalyst was the very first ever to be offered to the petroleum refining industry. Its effectiveness has been proved through commercial operation in the production of thousands of barrels of both premium gasoline and aromatics from petroleum by the Platforming process. Discovered by Universal, Platforming was the first reforming process to utilize a platinum catalyst to improve the quality of gasoline, and to produce commercial quantities of benzene, toluene and xylenes.

This new catalyst manufacturing plant is but another example of Universal's continuing program of progress designed to offer the broadest possible service to the world-wide petroleum refining industry.

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Fig. 1793—125-pound Iron Body Bronze Mounted Gate Valve with tapered solid wedge. Made in sizes 2" to 30", inclusive.

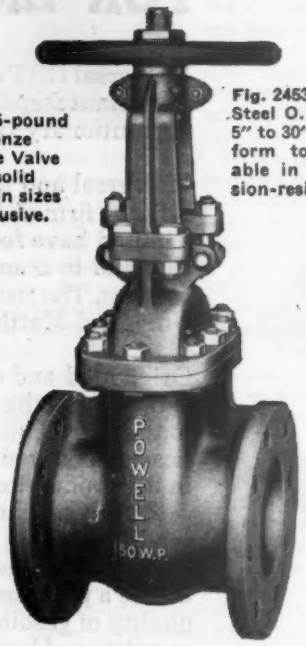

Fig. 2453-G — 150-pound Stainless Steel O. S. & Y. Gate Valve. Sizes 5" to 30", incl. All dimensions conform to latest standards. Available in a variety of other corrosion-resisting metals and alloys.

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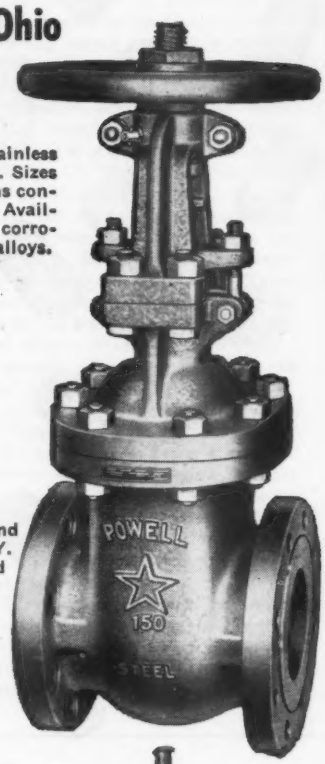

Fig. 1503—150-pound Cast Steel O. S. & Y. Gate Valve. Flanged ends and tapered solid wedge.

Fig. 3061—300-pound Cast Steel Swing Check Valve. Flanged ends and bolted cap. Disc has ample lift to permit full, straightway, unobstructed flow through the valve body.

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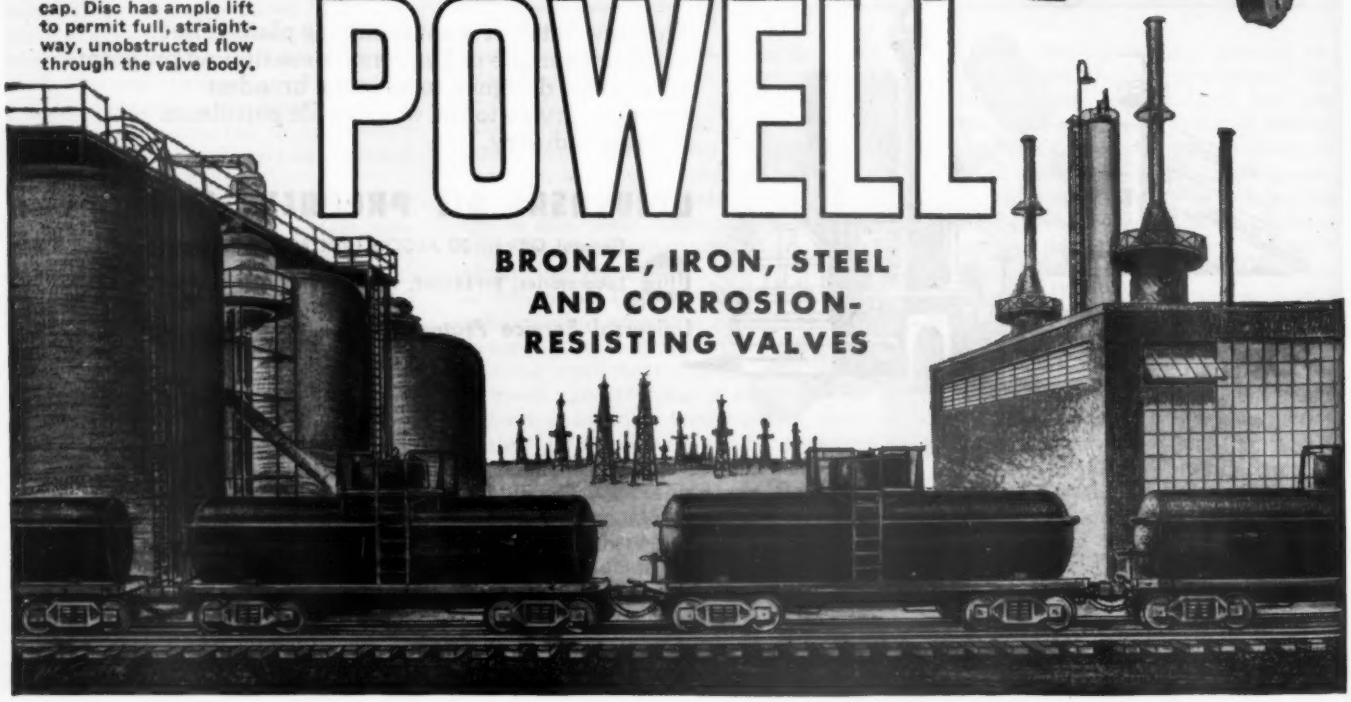

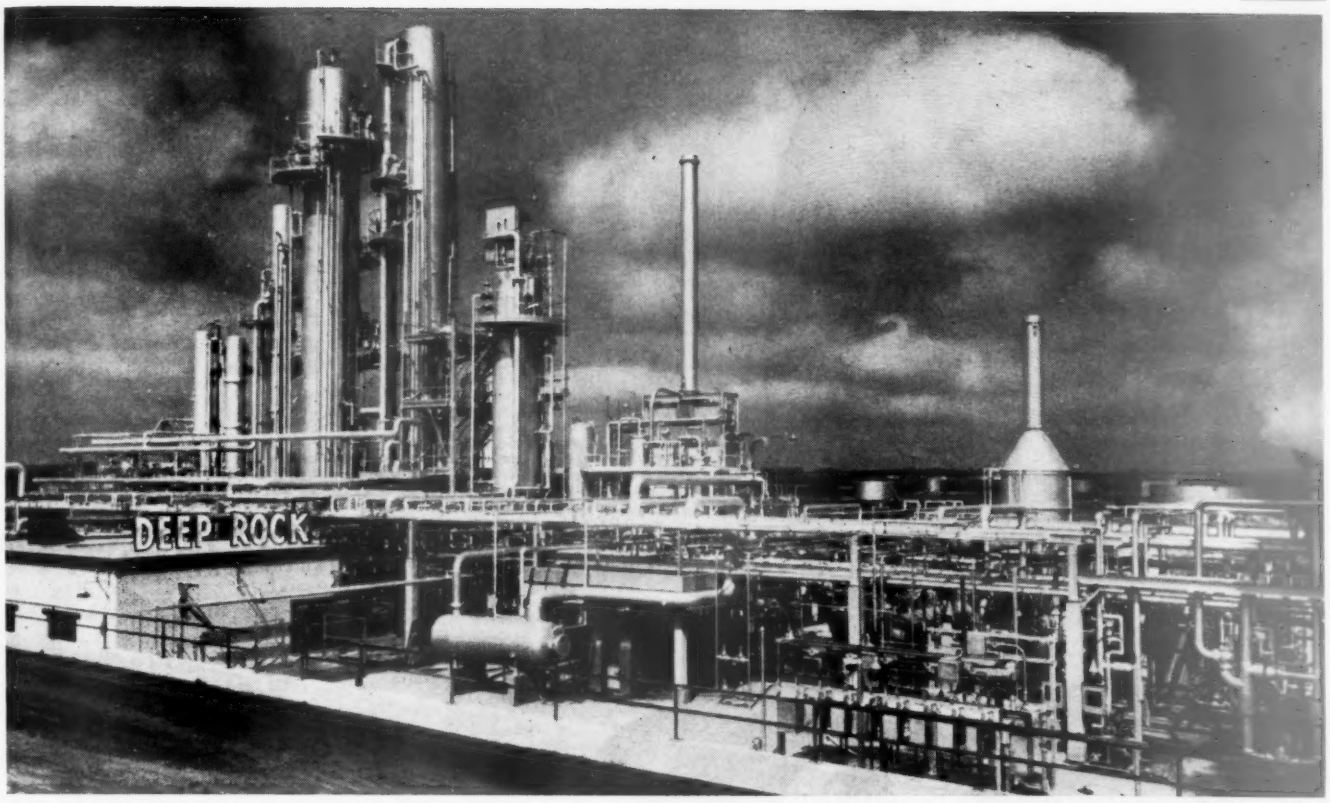

TOWERING SKYWARD from a hillside near Cushing, Oklahoma, is Deep Rock Oil Corporation's new $2,500,000 solvent lubricating oil plant, latest in a series of expansion projects. Largest tower in center of plant is tall as an 11-story building. Plant is now "on stream" and producing top quality lubricating oils, including Deep Rock's premium motor oil, Air Race HD.

Deep Rock Puts Solvent Oil Plant in Operation

A new $2,500,000 solvent lubricating oil plant has been put into operation at Deep Rock Oil Corporation's refinery at Cushing, Oklahoma, officials disclosed. The plant is the latest in a sizable expansion program for the refinery.

Not only have the new units modernized the plant and improved the quality of products, but daily crude oil intake has been increased from 12,400 bbl in 1948 to the recent rate of 19,000 bbl.

Test runs have been completed and the modern solvent lubricating oil plant is "on stream." The new units use phenol and propane as the treating agents for oil. Previously, sulfuric acid was used.

It was designed and constructed by The M. W. Kellogg Company. The Refinery Engineering Company built auxiliary facilities such as tankage, a water cooling tower, and other off-site units.

A feature of the plant is automatic control of all phases of operation.

NGA Seminar Announced

A two-day Seminar on the practical aspects of hydrocarbon analysis is being scheduled by the Natural Gasoline Association of America in the Texas Hotel, Fort Worth, September 21-22.

Using classroom arrangement and procedure, the Seminar will consist of a series of lectures, quiz panels, question periods and demonstrations. Sessions of the first day will feature discussions by A. J. Miller, Phillips Petroleum, on comparative analysis; S. T. Preston, instructor, NGAA Fractional will cover all phases of low temperature fractional analysis of both gases and liquids, S. L. Cahn, Beckman Instrument, will discuss analysis by infrared spectroscopy, and A. P. Gifford, Consolidated Engineering, will speak on "Hydrocarbon Analysis by Mass Spectrometer."

Second day sessions will be devoted to discussions of low temperature fractionation techniques and auxiliary techniques in forums led by S. T. Preston, Dan Smith, chief, Analytical Laboratories, Phillips, and Dr. Walter J. Podbielniak, Podbielniak, Inc.

Shell Chemical Reports New Plant in Louisiana

A substantial addition to America's supply of glycerine and epon resins will result from a new Shell Chemical plant to be erected at Norco, Louisiana, Richard C. McCurdy, president of Shell Chemical Corporation, has announced.

With construction starting immediately and completion scheduled for late 1954, the new plant will produce allyl chloride and epichlorohydrin. Its output will be used to increase Shell Chemical's glycerine production by 25,000,000 lb per year, McCurdy stated.

Epichlorohydrin is a vital component of many chemical products, including Shell Chemical's epon resins.

The Norco plant, an entirely new site for Shell Chemical, is designed to operate in conjunction with the Shell Oil Company refinery there and will use propylene and other feed stocks.

Sinclair Studies Process Of Oil Shale Recovery

A small field experiment to evaluate commercial possibilities of developing oil from shales is being conducted by Sinclair Research Laboratories, Inc., in western Colorado.

According to reports the Shell group is trying to develop a process designed to take oil from underground shale without the use of mining, retorting equipment, and crushing.

Majority of Sinclair's oil shale properties in western Colorado are on top of a mesa, and fenced for cattle grazing. They are about 17 miles from Rifle, Colorado, where the Federal Bureau of Mines has had an oil shale experimental station for several years.

A report from the experiment grounds states that the process has reached the stage where oil can be produced from shale at costs only a little higher than from petroleum.

Warren Gasoline Plant Begun

Warren Petroleum Corporation has announced construction of its Saunders natural gasoline plant, northwest of Lovington, New Mexico, has begun with completion scheduled for February 1, 1954.

This new plant will process gas from the Bagley, Hightower, Lazy J, North Saunders, and Saunders pools in the northwest corner in Lea County, and any future oil pools that may be developed in the that area. The Fluor Corporation, Ltd., has the contract to construct the plant.

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In these critical days, when "Defense is Everybody's Job" the Payroll Savings Plan is up front with America's defenders. Month after month, in upwards of 21,000 companies, more than 8,000,000 men and women are building a bulwark of thrift dollars. In January, 1951, 3,587,000 $25 Defense Bonds and 1,028,000 $50 Defense Bonds were purchased—the majority by serious savers on the Payroll Savings Plan.

Management is doing its part—in a big way. Hundreds of companies, large and small, are reinstating the Payroll Savings Plan or vitalizing the existing plan by a person-to-person canvass that puts a Payroll Savings Application Blank in the hands of every employee. No pressure is exerted—or needed. In Mr. Mueller's American-Standard plants, for example, the person-to-person canvass added 7,800 more employees to the plan that protects.

If your company does not have a Payroll Savings Plan . . . or if you have not made a person-to-person canvass recently . . . phone, wire or write to Savings Bond Division, U. S. Treasury Department, Suite 700, Washington Building, Washington, D. C. Your State Director will be glad to help you.

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The Petroleum Engineer

Small Changes in 1953 Summer Octane Ratings

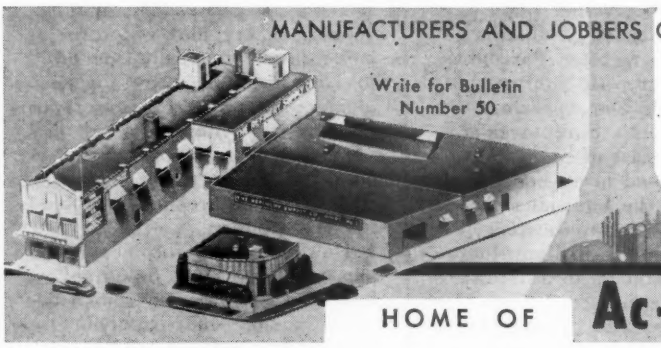
Relatively small changes are shown in the results of the duPont Survey of octane ratings in commercial motor fuels in the United States and Canada for its July 1953 report. Apparently the greatest change from earlier 1953 reports is found in the data from Milwaukee, where premium grade octane ratings are upped from Research 91.4 in January and April to 93.5 in July. El Paso, low in values last year once or twice, dropped its Research premium rating average from 90.6 and 90.3, January and April, to 89.3 in July.

Looking at the extremes, the highest Research premium grade rating is shown for Milwaukee, the low is 87.9 in Calgary, Alberta. In fact three of the four "lows" are found in Canadian towns. High TEL content in premium grades was found in El Paso gasolines, 2.92 cc per gal, practically at the limit of three cc. Among regular gasolines the highest octane rating (Research) was at Boston, Cleveland and Philadelphia, each showing an 87.7 average. The low was in Salt Lake City, probably reflecting the lower octane rating requirements of the mountain country. High TEL content of regular grades was at Atlanta, 2.73 cc per gal. Edmonton, Alberta showed low TEL content of 1.12 cc per gal.

Averages for the 48 cities surveyed are shown in the accompanying table.

DU PONT SURVEY OF OCTANE RATINGS — JULY, 1953

	Premium			Regular		
	Octane number		Tel content	Octane number		Tel content
	Motor	Research	cc/gal	Motor	Research	cc/gal
	July	July	July	July	July	July
Aberdeen, South Dakota	82.1	89.4	2.06	78.6	83.4	1.62
Amarillo, Texas	81.1	88.6	2.29	77.9	81.1	2.48
Atlanta, Georgia	82.9	92.6	2.26	80.7	85.8	2.73
Bakersfield, California	83.9	89.1	2.86	76.7	80.7	1.82
Baltimore, Maryland	84.1	93.0	2.62	81.4	87.6	2.23
Boston, Massachusetts	83.2	92.4	2.26	81.2	87.7	2.28
Calgary, Alberta	79.7	87.9	2.78	77.2	82.4	2.31
Casper, Wyoming	80.4	89.1	1.77	75.8	81.8	1.34
Charlotte, North Carolina	83.2	92.1	2.31	80.6	85.8	2.36
Chicago, Illinois	82.8	90.1	2.38	79.1	84.1	2.24
Cincinnati, Ohio	83.5	92.0	2.76	80.7	86.6	2.54
Cleveland, Ohio	83.7	92.4	2.65	81.2	87.7	2.23
Columbus, Ohio	83.2	92.1	2.76	80.7	87.5	2.38
Corpus Christi, Texas	85.4	91.9	2.61	82.6	84.7	2.56
Dallas — Fort Worth, Texas	83.4	92.1	2.67	80.2	84.3	2.55
Denver, Colorado	81.2	89.1	1.69	76.8	80.8	1.55
Detroit, Michigan	84.1	92.5	2.71	80.4	86.6	2.47
Edmonton, Alberta	81.1	88.6	1.76	77.0	82.9	1.12
El Paso, Texas	82.4	89.3	2.92	77.3	80.4	2.65
Great Falls—Billings, Montana	80.8	91.0	1.99	76.3	83.2	1.56
Houston, Texas	84.3	92.2	2.61	80.9	85.8	2.60
Indianapolis, Indiana	82.4	90.6	2.54	79.3	84.3	2.36
Jacksonville, Florida	82.7	92.1	2.05	80.2	86.3	2.30
Kansas City, Missouri	83.0	90.0	2.36	79.4	83.5	2.04
Little Rock, Arkansas	83.4	92.0	2.66	80.6	85.2	2.32
Los Angeles, California	81.9	91.0	2.32	77.1	82.6	1.96
Louisville, Kentucky	83.0	91.8	2.71	80.2	85.5	2.54
Memphis, Tennessee	83.2	91.5	2.70	80.4	84.6	2.63
Milwaukee, Wisconsin	84.4	93.5	2.71	78.5	84.4	1.96
Minneapolis, Minnesota	83.1	89.9	2.45	79.4	83.7	1.88
Montreal, Quebec	82.3	91.1	2.06	80.3	87.3	1.64
Nashville, Tennessee	82.9	91.8	2.58	80.0	84.8	2.61
New Orleans, Louisiana	84.2	92.3	2.78	80.5	85.4	2.42
New York, N. Y. (Metropolitan Area)	83.7	92.4	2.34	81.2	87.6	2.07
Omaha, Nebraska	82.8	89.7	2.21	79.5	83.1	1.90
Philadelphia, Pennsylvania	83.0	92.7	2.34	80.8	87.7	2.41
Pittsburgh, Pennsylvania	82.8	92.3	2.36	80.6	87.6	2.18
St. Louis, Missouri	82.2	90.0	2.35	78.8	83.3	2.17
Salt Lake City, Utah	82.0	88.5	1.97	76.8	80.3	1.46
San Francisco, California	82.6	90.9	2.29	77.1	82.2	2.00
Seattle, Washington	82.4	90.6	2.39	77.8	82.1	2.18
Shreveport, Louisiana	84.6	91.9	2.64	80.9	84.6	2.39
Spokane, Washington	81.8	90.3	1.98	77.0	82.2	1.63
Toronto, Ontario	82.2	91.0	1.90	79.5	86.6	1.63
Tulsa, Oklahoma	83.8	90.5	2.51	80.0	83.2	2.02
Vancouver, British Columbia	83.2	90.3	2.78	80.4	82.6	2.28
Wichita, Kansas	83.8	90.6	2.44	80.0	83.1	1.82
Winnipeg, Manitoba	80.4	90.1	1.37	78.6	84.8	1.21



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News

AIChE Plans All-Day Meeting in Oklahoma

A state-wide all-day meeting of the American Institute of Chemical Engineers is being held in Oklahoma October 10, 1953.

Each fall the Tulsa and Oklahoma sections hold a state-wide all-day meeting with the two sections alternating as hosts, with the Oklahoma section as host this year. Meeting will be held in the College High School, 1700 Hillcrest Drive, Bartlesville. Four technical papers will be given at the morning session, and W. T. Nichols, president of AIChE will give an address at the luncheon. Afternoon session will be devoted to a series of papers on personal improvement. Preregisteration or reservations for the luncheon are not necessary, according to P. Morgan Warzel, publicity committee, State-Wide Meeting.

TCR Unit Plans Announced

General Petroleum's Torrance, California, refinery has begun building a new thermofor catalytic reformer (TCR). The new process is a continuous method of upgrading low quality gasoline stock to a gasoline which, with the addition of tetraethyl lead, will have an octane number of 100 or more. Scheduled for completion July, 1954, it will produce about 15,000 bbl (of 42 gal each) daily of high quality gasoline blending stock.

The TCR process was developed by Socony-Vacuum Oil Company, Inc., with which General Petroleum is affiliated.

Construction of the unit will be under the supervision of C. M. Reading, General Petroleum's engineering department manager, with B. L. Rodzianko, project engineer, and Howard Rustad acting as construction engineer. Bechtel Corporation is the contractor.

Carthage Shutdown Termed Temporary by RFC

The Reconstruction Finance Corporation has announced that shutdown of the Carthage hydrocol plant at Brownsville, Texas, is only temporary and therefore they are not concerned with the $18,500,000 loan made the plant recently.

An RFC spokesman reported that it had been notified in advance of the shutdown that is being made for repairs and rehabilitation and, also that the firm had repaid $75,000 of the loan. The government has substantial collateral including the plant itself, the spokesman added.

UOP Forms Foreign Catalyst Manufacturing Subsidiary

Universal Oil Products Company has formed a new foreign catalyst manufacturing subsidiary in conjunction with Johnson, Matthey and Company, Ltd., well known London, England, platinum refiners.

The new firm is Universal-Matthey Products, Ltd., with headquarters at 78 Hatton Garden, London. Universal-Matthey will manufacture and make available in the sterling market UOP Platforming catalyst for use by refineries in producing premium quality gasoline. Procon (Great Britain), Ltd., will build the new plant, which is expected to go into production in mid-1954.

Harris announced that C. D. Sims of UOP has been named general manager of Universal-Matthey. George Orescan, Universal's assistant treasurer, is assistant secretary of the new firm.

Johnson, Matthey and Company officials who are officers of Universal-Matthey are L. C. Montague, a managing director, named chairman, and P. D. F. Varrall, secretary, who occupies a similar position with the new firm.

Hydrocarbon Research Named To Constructors Group

Hydrocarbon Research, Inc., specialists in the design and construction of facilities for the petrochemical and petroleum industries, has been elected to membership in the National Constructors Association.

The National Constructors Association is an organization composed of leading engineering and building firms engaged in the design and construction of chemical plants, steel mills, and petroleum refineries.

Recycling Plant Underway For Louisiana Fields

Construction of a recycling plant in the 14-well South Sarepta gas-distillate field in Bossier and Webster Parishes, Louisiana, has begun with Sunray Oil Corporation manager and operator of the project. The South Sarepta field, about 30 miles northeast of Shreveport, was unitized and closed in on February 2, 1953, by order of the Louisiana Conservation Commission on application of the operators. Sunray is drilling four additional wells designed to establish the boundaries of the field.

The operators expect to increase the field's production of condensate by more than one-fifth and the royalty owners stand to gain about 75 per cent on the unitization, stripping the LPG products from the wet gas and returning the dry gas to the ground to maintain reservoir pressure.

New Plant to Produce Platinum-Type Catalyst

Construction has begun on a plant in Newark, New Jersey, to produce a new platinum-containing catalyst for use in reforming petroleum it was announced by Charles W. Engelhard, president of Baker and Company, Inc., a member of the Engelhard Industries group. The catalyst to be produced is the result of joint reseach by the Sinclair Research Laboratories, Inc., a subsidiary of Sinclair Oil, and by the research laboratories of Baker and Company. It will be known as Sinclair-Baker Catalyst RD-150. Plant will be gin operation early in 1954.

Standard of Cal Initiates Refinery Expansion Program

A $30,000,000 refinery program designed to increase substantially the quality and octane ratings of motor gasolines was announced by T. S. Petersen, president of Standard Oil Company of California.

The upgrading of gasolines to qualities not normally reached by manufacturers of motor fuel will be accomplished principally by construction of two large catalytic reformers. One is to be built at the company's Richmond refinery, and other at its El Segundo plant, Petersen said.

Cat Reforming Unit Planned

L. William Moore, president of Pan American Refining Corporation announced that The M. W. Kellogg Company has been authorized to construct a catalytic reforming unit at the Pan American Texas City, Texas, refinery. This unit is the final step in the present expansion program the Texas City refinery. The new catalytic reforming unit will have a capacity of 21,000 bbl a stream day and will use a process developed jointly with Standard Oil Company (Indiana). It is expected that the new catalytic reforming unit will be completed and in operation in the Fall of 1954.

Texaco to Expand its Amarillo, Texas, Plant

Expansion plans for its Amarillo, Texas, refinery that will raise its crude distilling capacity from 8500 to 15,000 bbl per day has been announced by S. M. Johnson, Texas Company superintendent of that plant. The present permanent refinery force of about 150 employees will be practically doubled by the expansion.

New units and facilities to go into the plant include an Orthoflow fluid catalytic cracking unit, a delayed coking unit, catalytic reformer, an alkylation and a catalytic polymerization unit. Old existing crude distilling units will be replaced entirely. The coker and the crude units will be integrated into a combination unit, eliminating intermediate storage and "surge" capacity, intermediate cooling of fractions, and reduction of both construction and operating costs.

The delayed coking unit will be of 3600 bbl per day capacity; catalytic cracking, 6000 bbl fresh charge; and the polymerization unit will make 470 bbl per day of polymer gasoline. In addition to these main process units three new 150,000 lb per hour steam boilers will be installed with auxiliaries, and new laboratory and warehouse buildings will be constructed. M. W. Kellogg Company has most of the work contracted, and the new plant is expected to be on stream late in 1954.

XUM

The Greatest Gasoline Development in 31 Years

TCP*, a Shell discovered additive now blended into Shell Premium Gasoline, sets the pace for the fuels of tomorrow. It's another milestone in Shell's petroleum research.

The long-recognized problem of power loss due to combustion by-products has been solved by Shell research. No longer need these by-products cause the waste of fuel and power associated with missing spark plugs and with pre-ignition.

Shell research has discovered and developed a fuel additive now in Shell Premium Gasoline—called TCP. This additive actually changes the character of harmful deposits *within the engine* so that faulty spark plug operation and pre-ignition are eliminated promptly—often during the second tankful. Old *and* new engines benefit alike.

Shell TCP additive was originally developed for aviation fuels. Up until now it has been restricted to military planes. Without question it is the greatest fuel development since the introduction of tetraethyl lead in 1922.

Important as TCP additive is for cars today, perhaps the greatest significance is its great promise for the future. TCP additive points the way to lighter, more powerful engines—engines with much greater design efficiency than has heretofore been possible.

TCP is Shell's trademark for this additive. It is another example of the progressive research that goes forward day and night in Shell laboratories. It is evidence again that Shell research provides more and better products from petroleum.

*Patent applied for

SHELL OIL COMPANY

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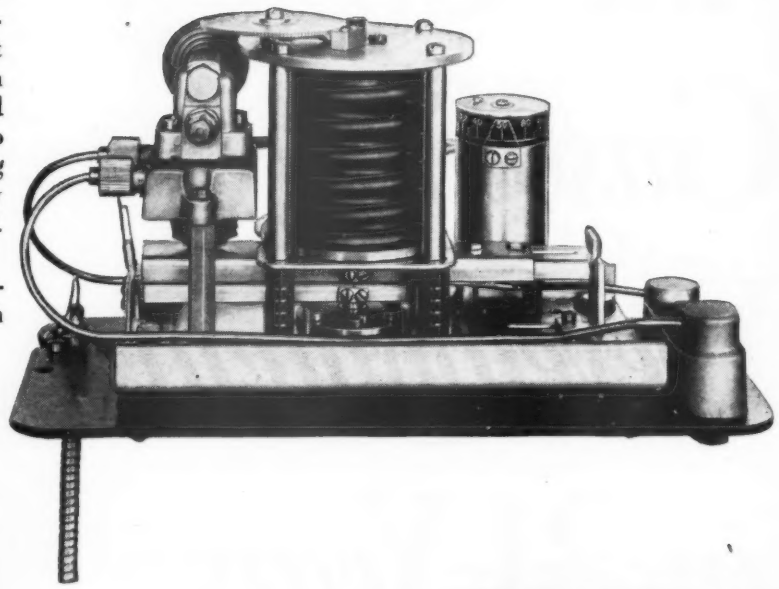

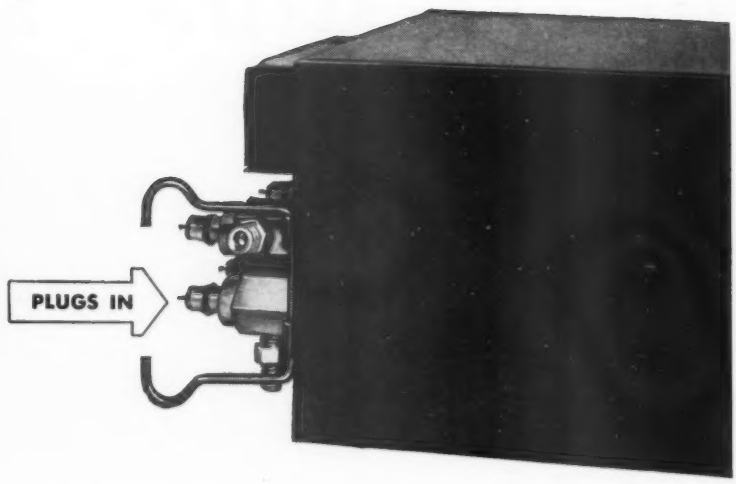

*Trade-Mark

THE BRAND NEW TRI-ACT* CONTROLLER combines all 3 response adjustments (gain, reset rate and PRE-ACT* response.) It is the most complete controller, giving the very best control on the more complex processes, particularly those with long time constants, and load changes, requiring both derivative and reset adjustments. Gives faster recovery on load changes; start-up without overpeaking; the benefits of automatic reset without its evils.

The One Knob and Two Knob BI-ACT* Controllers are interchangeable with the TRI-ACT controller in a matter of seconds. They are ideal for those applications where control requirements are less demanding.

RUGGED SELF PURGING SLEEVE OR CASE keeps out corrosive fumes, dust and dirt and gives mechanical protection to receiver mechanism. One common, self sealing manifold gives plug-in connections to both receiver and controller. You save panel space, because units can be mounted only a few inches apart. You save money, both in labor and materials on installation, thanks to the simplified piping and mounting.

why you should look at the CONTROL SYSTEM

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1. Ruggedness. Large, powerful bellows in all receivers to assure positive actuation. The TRANSET system is not laboratory instrumentation. It is built for rugged industrial use. In fact, mountings attach to panel so sturdily that they support the weight of an average man.

2. Dependability. TRANSET controllers have rugged diaphragms that will take pulsating signals without failure. The force-balance principle provides for minimum air use, hence less chance of clogging. O-ring seals on plug-in connections eliminate internal port leaks. The receiver case is self-purging.

3. Accuracy. Both indicating and recording receivers are calibrated to an accuracy of $\pm\frac{1}{2}\%$.

4. Flexibility. Due to plug-in feature both BI-ACT and TRI-ACT controllers and indicating and recording receivers are instantly interchangeable, making "second guessing" entirely practical.

Your Taylor Field Engineer will be glad to demonstrate these features. It will cost you nothing to call him in, and may save you both money and headaches. Write for **Bulletin 98097.** Taylor Instrument Companies, Rochester, N. Y., and Toronto, Canada.

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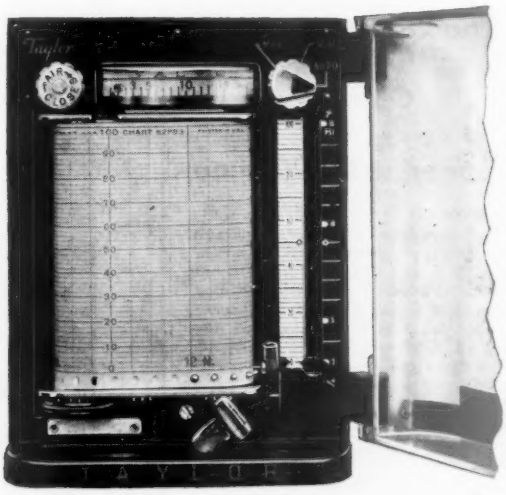

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THE TRANSET SINGLE PEN RECORDER has automatic-manual unit; remote set-point indicator; 30 day linear chart, 3 hours visible. Chart reads from left to right on rectilinear coordinates, as an engineer would normally plot variables for study. Continuous valve position indicator on separate scale tells valve air pressure at a glance. Chart read-back device gives easy access to past records. Other receivers include: Single Duty Bi-Record Receiver, Pneumatic Set Receiver, the TRANSET Indicator. On all instruments adjustments can be reached conveniently from the front.

News

Catforming Process Begins

Third of a series of installations of The Atlantic Refining Company's catforming process has begun successful operation, the company announced. The unit, a 1000-bbl per day catformer, is in the Husky Oil Company's refinery in Cody, Wyoming.

It will produce high octane gasoline by the new process developed in Atlantic's research laboratories. Atlantic is licensing the catforming process to a number of other refiners.

Dow Research Center Will Honor W. R. Veazey

Dedication of a new $2,600,000 research center at The Dow Chemical Company's Texas division in honor of Dr. William Reed Veasey, recently retired Dow director and research consultant, is announced by Dr. Leland I. Doan, company president.

The research center, which has been under construction at Freeport, Texas, for more than a year, will be completed in September and it will be formally dedicated to Dr. Veazey at a meeting of general research committee in October.

New Concern to Build Anhydrous Ammonia Plant

The Mill Creek Chemical Company, a newly formed independent concern, has announced plans for building an anhydrous ammonia plant in the Salt Lake City, Utah, area.

Organization and financing of the company is being handled by Glore, Forgan and Company of Chicago and New York, investment bankers, and the plant is to be built by Tears Engineers and Henry C. Beck Company, of Dallas, Texas.

The new facilities are to have a daily capacity of 180 tons of anhydrous ammonia. The plant will also produce over 30 tons of dry ice daily.

Anhydrous ammonia output of the Mill Creek Chemical Company will be sold to manufacturers of ammonium phosphate, ammonium sulfate and other chemical products using ammonia. The products will also be sold to distributors of anhydrous ammonia for direct application as an agricultural fertilizer.

For further information contact Glore, Forgan and Company, 1510 Mercantile Securities Building, Dallas.

PAD Attempts to Insure Meeting Alkylation Goal

Applications for necessity certificates for construction or expansion of refining facilities are being carefully reviewed by the Petroleum Administration for Defense to insure as far as possible provision for needed alkylation facilities, Deputy Petroleum Administrator Joseph A. LaFortune has reported.

"We are still short some 20,000 bbl a day of the alkylation facilities we need to cover estimated wartime needs for aviation gasoline," LaFortune said.

Since October of 1951, when the Armed Services Petroleum Purchasing Agency was given an $85,000,000 fund to back facilities contracts for the production of alkylate, PAD has been pressing for an expansion of production facilities beyond present capacities by 30,000 bbl a day. This goal was made formal by the Office of Defense Mobilization on April 30, 1953.

"So far, though," LaFortune said, "projects filed for PAD recommendations of accelerated tax amortization cover roughly only 10,000 bbl a day of the program."

"Our present policy is to ask all applicants who say they plan any major new construction or expansion to check carefully the possibility of including an alkylate unit in their project."

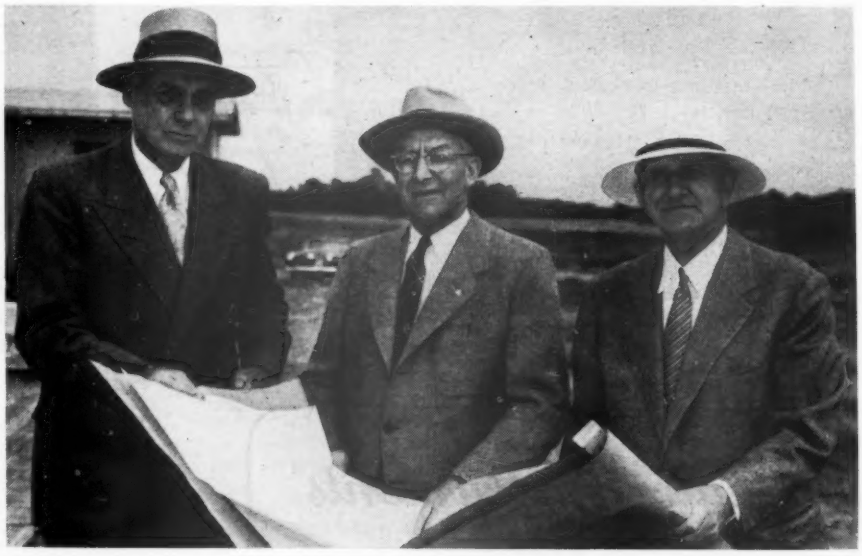
Platforming Unit Due For Shell's California Plant

Plans to construct a $1,700,000 Platforming unit at the Shell Oil Company refinery at Martinez were announced by refinery manager John Tench.

The Platforming unit will be designed to take low octane gasoline stocks and, through a catalytic reforming process using platinum as the catalyst, boost the quality of the fuel as much as 25 octane numbers. Tench disclosed that C. F. Braun and Company will construct the Platforming unit, and actual work will commence immediately. The Platforming unit is expected to be in operation by July of next year.

AIChE Meeting Set

The New York Section of the American Institute of Chemical Engineers will conduct a Symposium on October 22, 1953 at the Hotel New Yorker, New York City. The Symposium will be an all-day meeting in two sections and will cover the topics of "Management," and "New Materials of Construction" and "Solids Handling."



NEW ERA of industrial development in Pacific Northwest was predicted at dedication ceremonies in Ferndale, Washington, by B. Brewster Jennings, president, Socony-Vacuum; R. L. Minckler, president, General Petroleum; and S. D. Bechtel, president, Bechtel Corporation, as they inspect plans for General Petroleum's new $35,000,000 refinery. The plant, now being designed and constructed by Bechtel Corporation, will process crude oil from Alberta fields, brought to the Pacific Coast by the Trans Mountain Oil Pipe Line. The new refinery is the first major petroleum processing plant for the Pacific Northwest.

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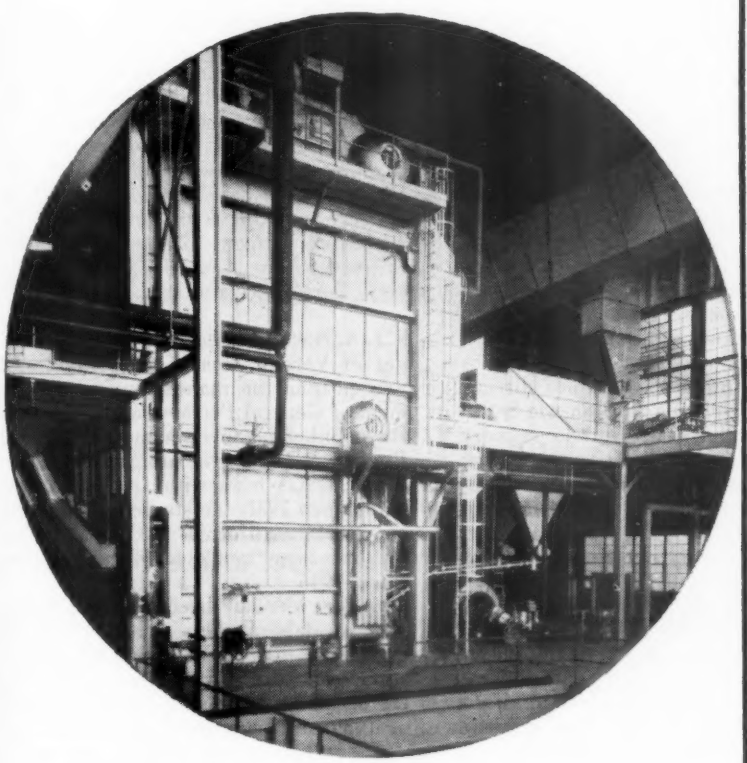
City of Manitowoc installs fifth WICKES steam generator

To provide a dependable source of power for the City of Manitowoc, Wisconsin, the Manitowoc Public Utilities Commission has just installed a fifth WICKES Steam Generator capable of producing 175,000 lbs. of steam per hour at 525 psi. Final steam temperature is 750°F. The new WICKES Boiler has 11,600 sq. ft. of heating surface. It is equipped with an economizer and fired by spreader stoker.



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150

REFINING AND PETROCHEMICAL

PERSONALS

▸ **W. P. Gee,** assistant to the president, The Texas Company; **L. C. Duncan,** assistant to the president, American Cyanamid Company; and, **S. C. Moody,** vice president, American Cyanamid Company, have been named to the board of directors of Jefferson Chemical Company.

The Jefferson board now consists of the following representatives of American Cyanamid Company and The Texas Company, joint owners of Jefferson: L. C. Duncan, W. P. Gee, M. Halpern, J. S. Leach, A. C. Long, W. E. Kuhn, S. C. Moody, L. C. Perkinson, R. L. Saunders, W. M. Stratford, R. C. Swain, K. C. Towe and M. C. Whitaker. P. M. Dinkins, president of Jefferson Chemical Company, is also a member of the board of directors.

▸ **W. J. Birmingham** has been appointed patent advisor in the Whiting, Indiana, research laboratories of Standard Oil Company. Birmingham recently received his law degree from De Paul University. A mechanical engineering graduate of Stevens Institute of Technology, he was awarded a master's degree in business administration by the Harvard University business school in 1948. The same year he joined Standard Oil Company.

▸ **Fred L. Hartley,** general superintendent of operations, Union Oil Company of California, was installed as president of the California Natural Gasoline Association recently. **A. C. Lyles,** chief gas engineer, General Petroleum Corporation, was elected vice president and **E. R. Millett, Jr.,** was again appointed secretary-treasurer.

Committee chairmen to serve during the next fiscal year include: Lyles, advisory; **L. V. Cassaday,** Lomita Gasoline Company, awards; **George C. McLaren,** Standard Oil, education; **Fred Carter,** Carter-Jones Company, entertainment; **D. R. Arnold,** Superior Oil, fall meeting; **M. L. Fort,** Pacific Lighting Gas Supply, finance and budget; **Fred C. Brunner,** C. F. Braun and Company, program; **E. R. Millett, Jr.,** publicity; **J. H. Watson,** Union Oil Company, technical, and **M. L. Arnold,** Richfield Oil Corporation, technical advisory. Twenty-three newly elected directors will serve for a two-year term of 1953-1955.

▸ **Jack W. Smalling** has been named assistant general foreman of light ends at the Baytown, Texas, refinery by Humble Oil and Refining Company's refining department. A graduate in chemical engineering from the University of Texas, he was a member of technical service division prior to his transfer into operations.

The following staff additions are also announced at Humble Oil's Baytown refinery: **Delos E. Bown,** PhD in physical organic chemistry, Massachusetts Institute of Technology, and **Thomas S. Farmer,** MS in chemical engineering, Princeton University, to research and development division; and **Ronald L. Anderson,** BE in chemical engineering, Vanderbilt; **William H. Dickerson,** BS in chemical engineering, Virginia Polytechnic Institute, **J. Irwin Jordan, Jr.,** BS in chemical engineering, Texas A & M College, and **Robert L. Seldomridge,** Georgia School of Technology, to technical service division.

After having served almost two years as a lieutenant in the U. S. Army, **Thomas H. Royder,** BS in chemical engineering, Texas A & M College was re-employed in the service division.

George R. L. Shepherd has been promoted to senior research chemist at Baytown refinery. He is a graduate of Georgia Institute of Technology.

▸ **John Wylie** has been named director of industrial relations at Pan-Am Southern Corporation's El Dorado refinery. He assumed the new position on September 1, replacing **James L. Ward** who resigned to become an industrial relations consultant.

Wylie, until receiving his new appointment, was assistant to T. G. Hanlon. He is a graduate of Oklahoma A & M.

Robert E. Mackay, who has served as personnel assistant in the El Dorado industrial relations department of Pan-Am, will move to New Orleans to fill the post vacated by Wylie. Mackay is a graduate of Arkansas University.

▸ **W. B. Logan** and **F. H. Holmes** have been promoted to assistant general managers of the refining department of The Texas Company.

Logan, who has been with Texaco since 1922, has been manager of operations of the refining department since 1950. Holmes was assistant manager of operations before his promotion. He has been with The Texas Company since 1927.

T. A. Mangelsdorf, general superintendent of Texaco's Port Arthur, Texas, Works since 1950, has been named manager of the operations division in New York. He joined Texaco in 1933.

Also announced were the following departmental promotions:

L. C. Kemp, Jr., director of research, has been appointed assistant to the vice president. Kemp has been succeeded as director of research by **Dr. W. J. Coppoc,** formerly associate director of research, and **Dr. C. E. Moser** has been made associate director of research. **Dr. R. L. Sawyer** has been advanced from supervisor of the fuels development research department to assistant director of research at Texaco's Beacon, New New York, Laboratories.

▸ **J. A. Boege** has been appointed manager of Vernon area of Los Angeles, a new post in the manufacturing department of General Petroleum Corporation. **R. A. Baker** has been named to succeed Boege as manager of laboratories.

Boege has been with General Petroleum since 1930. He studied at the University of California at Los Angeles. He had been manager of laboratories since 1945.

Baker, who has been assistant manager of laboratories, joined General Petroleum in 1933 following his graduation from the University of California. He became a senior chemical engineer in 1939 and superintendent of laboratories at Torrance in 1944.

Roger Clapp

Kenneth Danskin

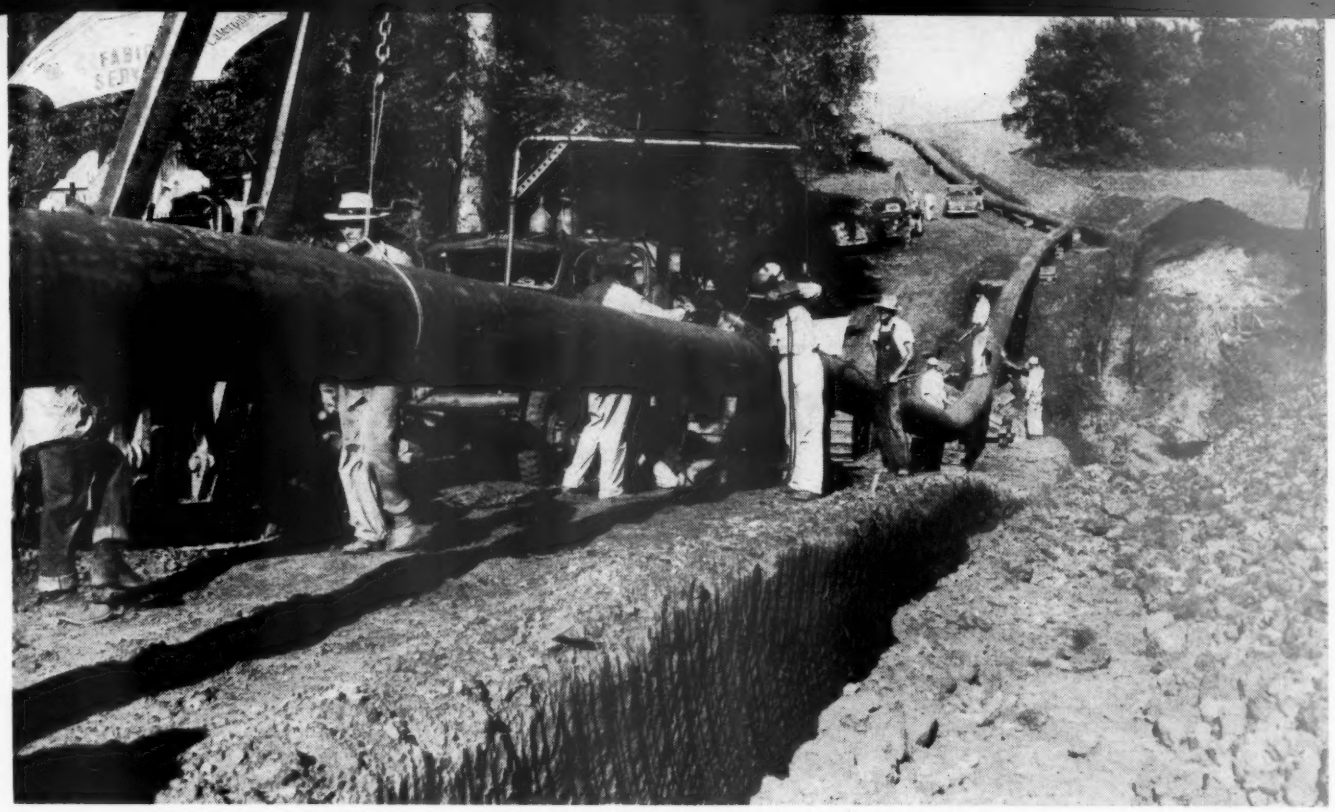
Matthew Payne

▸ **Roger Clapp,** who has managed the Lubrizol Corporation's Houston, Texas, plant since it was opened in 1951, is returning to Cleveland to become assistant manager of all manufacturing. **Kenneth Danskin** becomes manager of the Houston operation. In addition, **Matthew Payne** has been named as manager of Lubrizol of Canada Ltd., the subsidiary now building a plant near Niagara Falls, Ontario.

Clapp received his BS degree in mechanical enginering from Texas Technological College in 1933, and his MS from Purdue University in 1938. He first joined The Lubrizol Corporation in 1941.

Danskin came to Lubrizol in 1950, having been with the Texas Oil Company since 1931.

Payne, who will manage production of the company's chemical additives for lubricants in Canada, joined the company in 1949 as an industrial engineer.



In This Issue—

OPERATING OLDER STATIONS BY REMOTE CONTROL

One of the components of modernization programs for many companies engaged in pipe line transportation of crude oil and refined products is installation of remote control in smaller booster stations. Experiments with various types of remote control apparatus are currently underway in many companies. One test operation, underway in South Texas on an older existing crude line by Magnolia Pipe Line Company, is comprised of supervisory control equipment combined with regular telephone carrier. Almost "foolproof" in operation, the system has excellent operating, safety, and error prevention features. Functions include control of motor starting and stopping coupled with remote reading of station pressures. (Page D-4.)

SPEEDY LAYING OF 20-INCH SUBMARINE LINE HELPED BY PRE-PLANNING

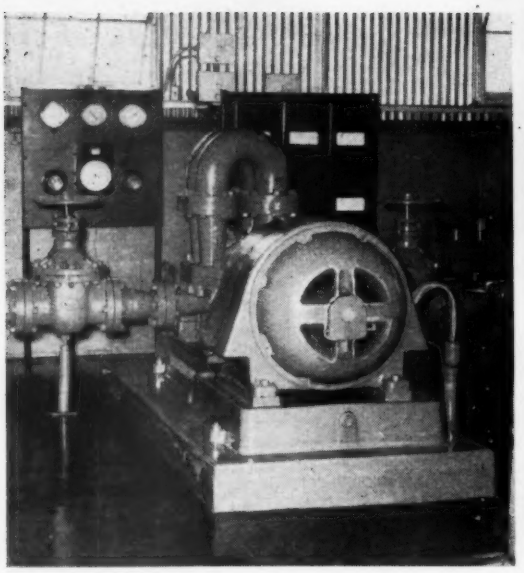
Careful organization of preliminary work through all stages enabled Pacific Coast contractors to lay a 20-in. submarine fuel line for San Diego Gas and Electric Company in record time. A study of ocean bottom conditions by divers, close cooperation between pipe supplier and constructors, properly timed construction of component jobs and excellent cooperation in all phases made the rapid accomplishment possible. (Page D-7.)

DEVELOPMENT OF A PROGRAM FOR UNDERGROUND STORAGE OF GAS

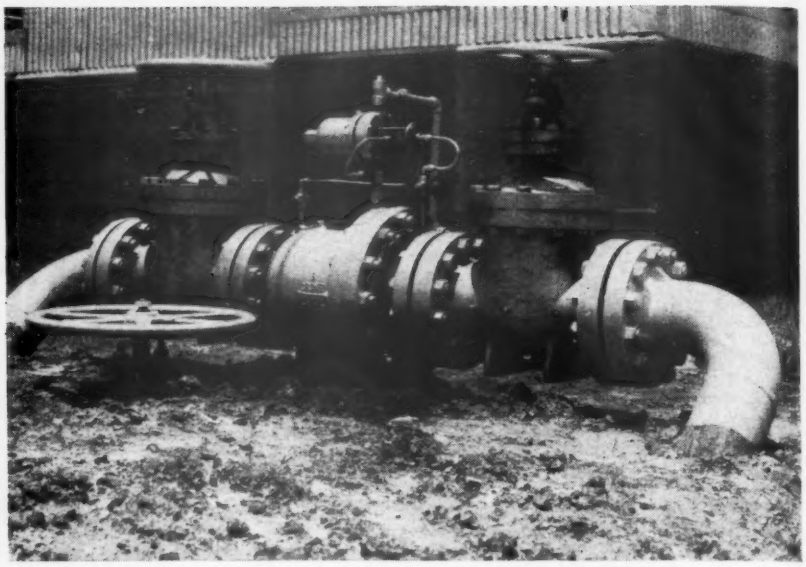
The complexity of meeting market requirements has caused many natural gas companies to turn to underground storage. Successful operation and protection of such storage depends on careful planning of each step in the development of such storage, including legal, geological, injection, pipe line systems for input and withdrawal, corrosion of equipment, measurement, and operations. Answers to questions on losses, accounting, turnover, and similar items can be found in the article. (Page D-10.)

COMMERCIAL SERVICES USED TO SOLVE COMMUNICATIONS PROBLEMS

Confronted with the problems of increased maintenance costs, limited space that hinders expansion of communications facilities and technical limitations on equipment, Buckeye Pipe Line Company has turned to private line teletypewriter service to improve its communications. As a result, the company reports increased efficiency, considerable economy and improved operations. Buckeye has nearly 3000 circuit miles of the private teletypewriter service. (Page D-25.)



INTERIOR of Waelder station. Station pressure gages on left, telemetering gages on right.



REGULATOR valve installed at Waelder station as safety device. It maintains constant suction pressure of 18 to 20 psi.

Remote Operation of Older Stations

Supervisory control system combined with regular telephone carrier in unique experiment on line

DEAN HALE*

SINCE March 1 Magnolia Pipe Line Company has had in operation a "guinea pig" project on its Mirando City-Beaumont crude line involving the use of remote control of a booster station through supervisory control equipment.

A relatively new development in the field of remote station operation, the initial installation of the system employs telephone carrier to dispatch and receive coded control operations.

The supervisory control system in use is a two-unit operation, in which the preceding station controls the next pumping station. Stations being used for the experimental project are Magnolia's Luling and Waelder stations in South Central Texas.

Luling, a storage and initial point, is the controlling station and Waelder is the controlled station.

Both stations are on Magnolia's 8-in. crude line that extends from Mirando City to Beaumont with a junction point at Sealy. Distance between the two stations is 22 miles.

Few changes had to be made in either station when the supervisory control system was installed. Addition of control equipment panels, telemetering equipment, and switch controls comprised the main changes.

The supervisory control system provides the operator with the information he needs at all times. The operator also has positive control over the remote station.

Operating Features

No sequence control is involved in the supervisory control system. In starting pumps at Waelder both suction and discharge valves are kept open. Additionally, this gives less starting load on the Waelder pumping units. The operation in this manner has proved satisfactory.

The supervisory control equipment used in the system is Westinghouse's "visi-code."

Control functions of the operator includes starting and stopping of pumps at the remote station. Observational functions are telemetering of station pressures at the remote station, including suction, intermediate, and discharge. The operator also has visual indication to show which pumps are on-line or not on-line.

There are five points on the operational sequence. By pushing an appropriate button, the control station sends to the remote station a unit selection or pressure selection code. The remote station repeats the code back to the control station. At the control station, the codes sent and received are compared and if the codes match, an "agreement" lamp is lighted. At this point, a selected pressure will be indicated or a selected pump unit will be ready for starting and stopping. In event pump units are to be started or stopped, this control is accomplished by pushing a "start" or "stop" button. Pump control lamps will then light to show the new condition at the remote station.

Error Prevention Features

Error in selecting operations is prevented through a selection check, in which agreement of transmitted and received selection codes is indicated by an agreement lamp. Unsatisfactory code comparisons will sound an alarm and prevent further operation under faulty conditions. This prohibits the supervisory equipment from selecting the wrong pressure or pump unit.

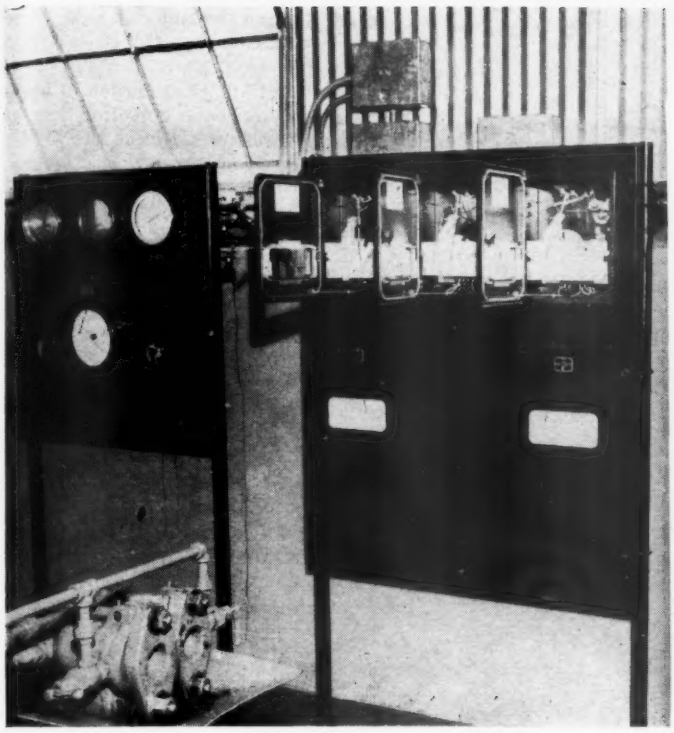
Once an operation is initiated by the control station that operation has priority over any signal initiated by the remote stations, such as failure of a unit other than the one being controlled. This control station preference prevents equipment from becoming "jammed" with simultaneous operations. The remote station signal is "stored" in the equipment until completion of the control station operations.

Operational conditions at the remote station can be verified any time at the control station by pushing a check button.

Power failure at Waelder station is

*Pipe Line Editor.

EXCLUSIVE



PANEL of telemetering pressure gages at right, which indicate suction, intermediate and discharge pressures. At left are regular station pressure gages and mercoid switches.

AUTOMATIC starting equipment is built into motor control panel. Transfer switch at top of panel allows operator to select "off," "hand," or "automatic" operation.

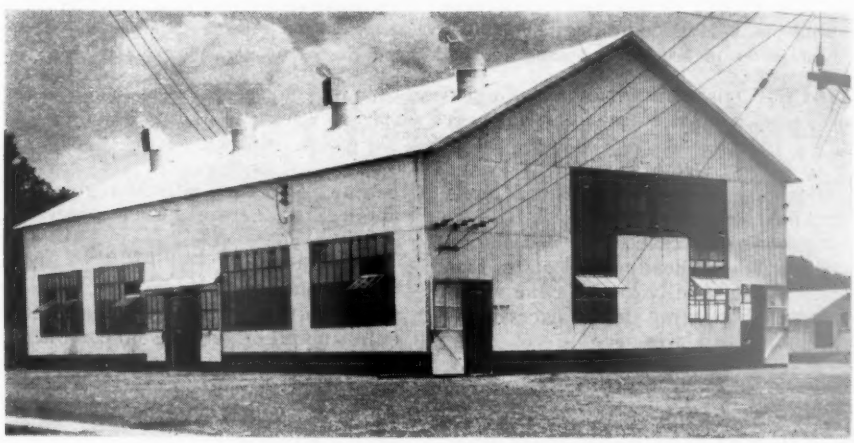
indicated immediately at Luling control station by an alarm. When power is restored, an additional alarm sounds. In event of over-pressure, low suction pressure, or motor overload, resulting in protective shutdown, an alarm sounds at the control station. At the remote station, cause of the trouble is indicated on an annunciator of the "dropdown" type. Power failure at Luling control station will automatically shut down the remote station due to low suction pressure.

Safety Features

Dual operation as a safety meaure is provided in the system through a selector switch at Waelder. The station engineer at the remote point can select either manual or automatic operation at any time. Transfer of operations can be made without shutdown at the remote station. In event of emergency or repairs, the system can be shut off entirely. This feature allows closer tie-in on operations. A separate phone channel allows the two stations to maintain constant communication whether the supervisory control is working or not.

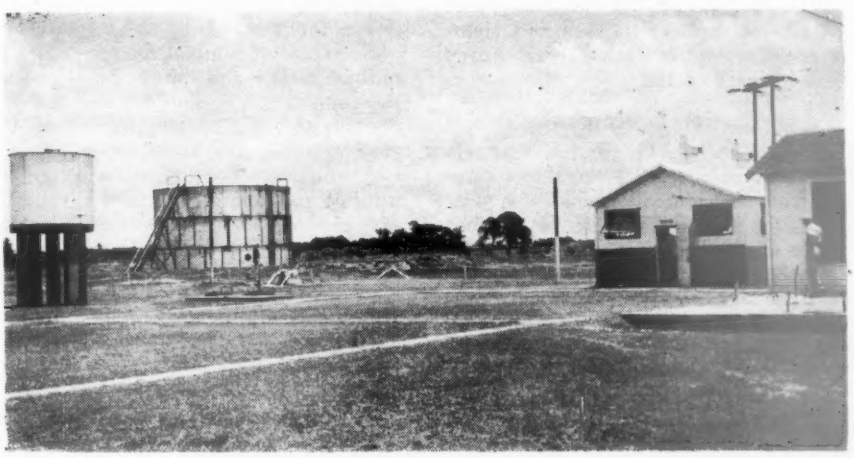
Power failure at the remote station is indicated at the controling station by an alarm. A line check valve at Waelder opens in such event, with flow bypassing the booster station until power and normal operations are restored.

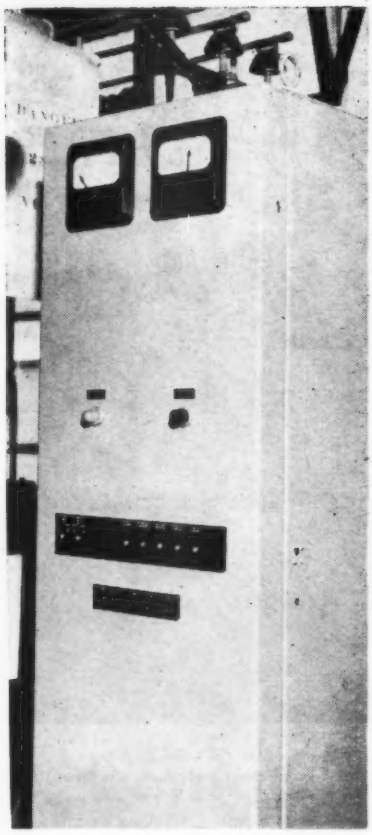
Safety devices installed at Waelder along with the supervisory control include a regulator valve to maintain a constant suction pressure of 18 psi. Previously, this was done manually by pinching valves. An automatic shutdown control of the mercoid switch for low

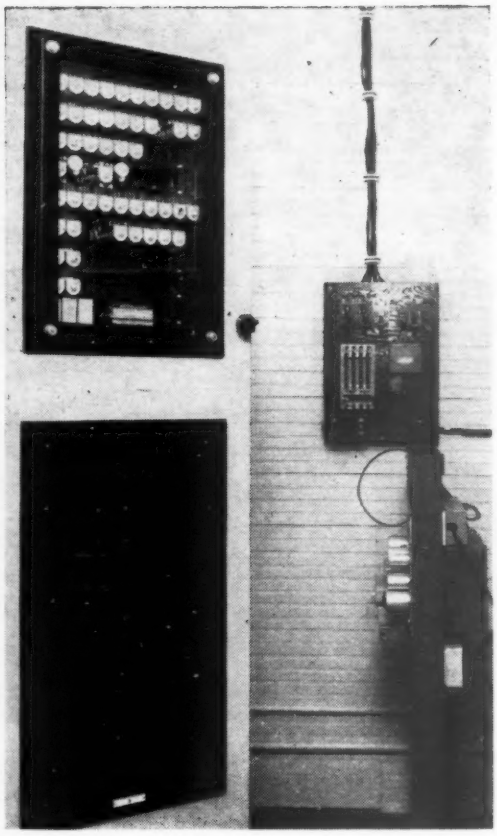


LULING station on Magnolia's 8-in. crude line, built approximately 30 years ago.

WAELDER booster station, situated 22 miles downstream from Luling station.







SUPERVISORY control panel (left photo) at Luling station, showing control pushbuttons, indicating lamps, and telemetering gages. Gage at left is for pressures to 400 psi and gage on right for pressures to 1000 psi.

CABINET (right photo) containing supervisory control equipment, left, is in same room as carrier equipment and power supply at Waelder station.

suction pressure or high discharge pressure has been installed.

Equipment planned for installation later includes a float control alarm that would automatically lock out the motor starting if packing leaks excessively, and sound an alarm.

Telemetering

The telemetering operation uses Bristol Meta-meters, which are of the time-impulse duration type. In this system the value of the measured variable is transmitted as a function of time rather than as an electrical magnitude. Synchronous motors are employed in the operation.

The supervisory control equipment operates to connect the selected meta-meter to the control station receiver over the telephone carrier.

Carrier Equipment

Two line wires or carrier channels are required to operate the remote station from the control station.

For the Luling - Waelder operation, carrier channels of 32.8 kc and 23.8 kc are used, the former for control dispatching and the latter for remote station checks and intelligence return. A separate voice channel for exclusive use between the two stations is also provided.

The carrier system is a part of the regular communications system of Magnolia. If necessary, the channels can be integrated back into the regular communications network when needed.

Control Equipment

Only one type of relay is used in the supervisory control equipment. It requires no oiling and has no complicated rotating parts. The relays used are similar to those used in automatic telephony and are the only moving parts of the entire equipment.

All transmitting and receiving equipment is housed in tall, narrow width and depth panel cabinets, one at each station. Carrier equipment is nearby at the remote station and in a separate office at the control station, with cables connecting the control panels and carrier equipment.

Each unit of controlled equipment has individual key and indicating lamps on the control panel. There are four components of the controlling panel for each unit.

A white selection lamp, when lighted, informs the operator that the supervisory equipment has completed selection and is ready for further operation.

A red lamp, when lighted, indicates the unit is in "closed" position and the unit is operating. A green lamp, when lighted, indicates the unit is in "open" position, ready to start or not in operation. The selection key allows the operator to pick a definite apparatus unit for an operation.

In addition to the individual key and lamps, five master control push-button keys are provided. Start and stop keys are used to initiate transmission of operator codes. When the selection key is pushed and breaker selected, the breaker is operated by either start or stop key.

A check key, when pushed, allows the operator to verify by lamp indication the operating condition of any device. An alarm key is provided to silence the automatic alarm bell after the supervisory control reports an automatic operation in the system. A reset key restores equipment to normal at-rest position at any time. It is also used to stop flashing of breaker indication lamp after a check has been made.

The relays in the control operate at split-second speed, giving the operator positive control at all times.

Whenever a breaker is tripped or closed by any means other than operator's control, an alarm is sounded and the controlling board notified.

Pilot Operation

A unique feature in the experimental installation of Magnolia's supervisory control operation is that the two stations selected for the operation are both older existing line stations. Both Luling and Waelder stations have been in operation nearly 30 years. The experiment is being conducted partially to test the operation of the supervisory control system and partially to test the practicability of adapting it to existing stations.

Waelder station is now an electric booster station. Until 1942, it was an oil engine station. It handles between 19,000 and 24,000 bbl per day, top capacity of the line. Light crude displacement is 22,500 bbl with the straight Mirando and 24,500 bbl with a blended Luling, Lytton Springs, and Darst Creek crude flow.

The station has two centrifugal pumps in series, which are 4-in., 3-stage, driven by 250-hp, 2200-v motors. A chief engineer is stationed at Waelder for maintenance and to handle delivery of some oil gathered in the area. The oil is delivered at the station via truck and pipe line. It is pumped into the main line during the period of the Mirando crude displacement.

Summary

During the period of operation since the March 1 inaugural, the supervisory equipment has functioned without any major trouble.

Results of testing to date indicate the system is almost ideally trouble free in operation.

Magnolia engineers point out, however, that further testing is necessary and some future changes may be made in equipment on this pilot operation.

The present use is limited to just two stations. Additional stations can be added, though, to increase the utility of the system.

Most widespread application of the supervisory control system would be for booster stations on closed line operations. ★ ★ ★

P 615.372

PIPE FABRICATING racks, showing side-boom cats laying a 270-ft pipe section on cradle cars.

JOHN ACORD, fitter foreman; Walt Cameron, welder, and Jack Bell, welder, talk over joining of two sections of pipe.

West Coast's Largest Submarine Line Laid in Record Time

Careful pre-planning was key to success of the project, which involved unusually large and heavy pipe

RICHARD SNEDDON*

LAYING of a submerged 20-in. fuel oil pipe line at Encino, California, for San Diego Gas and Electric Company was completed on June 1, 1953, by the joint action of Pacific Pipeline Construction Company of Montebello, and the Haviside Company of San Francisco. This line is reputed to be the largest internal diameter submarine line on the West Coast, and its fabrication and installation presented some difficulties, the solution of which will be of more than passing interest to pipe line engineers. The pipe, supplied by Consolidated Western Steel Company, has a wall thickness of 5/16 in., and weighs approximately 215 lb per foot coated.

Function of the line, which extends from shore facilities some 3200 ft into the Pacific Ocean and is submerged to a depth of 50 ft, is to provide a means of discharging fuel oil from tankers to the gas company's onshore tank farm. This fuel is then used in the firm's new steam generator plant.

*Pacific Coast Editor.

Preliminary studies were made of the ocean bottom over the proposed pipe line route by divers from the Haviside Company under the supervision of Henry Smith, operations manager of that firm. These studies were presented in a joint conference that included representatives of the gas company and both the contracting organizations. Immediately thereafter, an operating program was developed with Haviside in charge of the marine work, and Pacific Pipeline responsible for pipe fabrication and pipe coating.

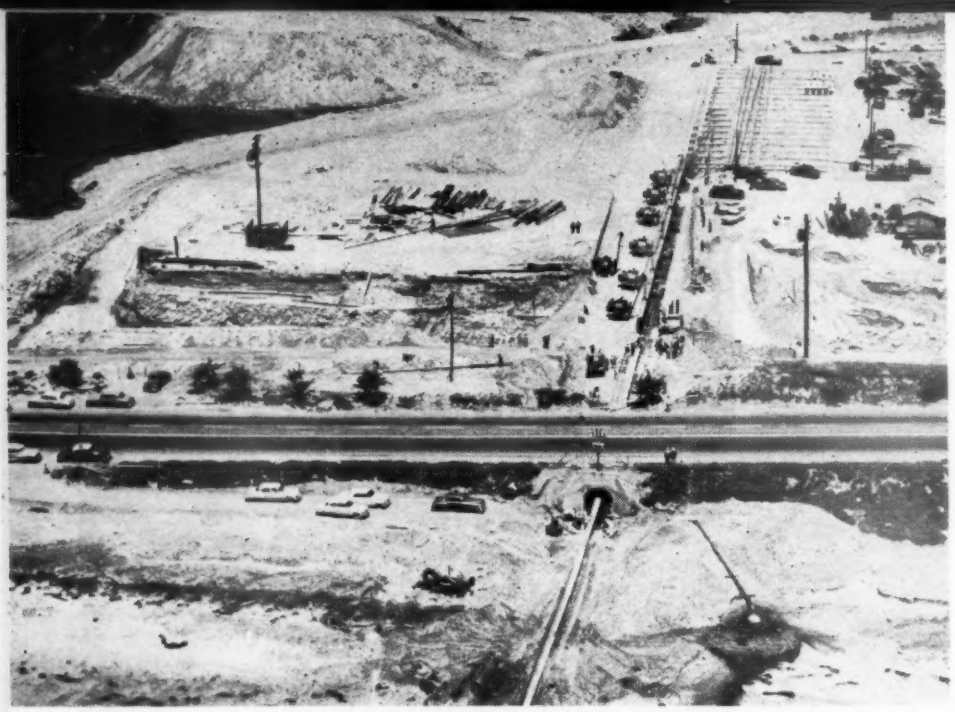
Onshore facilities for the handling and welding of the pipe in the field were set up by the latter, and precoated pipe was then brought in from Pacific Pipeline's Montebello plant. The plant treatment consisted of applying coats of water-works enamel, fiber glass, and 15-lb asbestos felt, after which a wire mesh was applied and the surface was gunited with concrete to produce the required negative buoyancy. The gunite coating also constituted protection from the scouring action of underwater currents.

EXCLUSIVE

A number of pipe racks were built from 6-in. by 6-in. and 8-in. by 8-in. timbers to simplify the process of fabrication. On these the pipe was welded into 270-ft strings. Upon completion, each string was loaded on to a cradle car with seven D-7 Caterpillar side-boom units aiding in the procedure. The cradle cars operated on a narrow gage railway that ran alongside the chosen route as far as was necessary.

The pipe line right-of-way required crossing of one of California's main thoroughfares, Highway 101, and that meant a sub-surface crossing. This was accomplished by jacking an 8-ft diam reinforced concrete pipe under the highway. Through the tunnel so formed, a heavy steel trough was installed on I-beam supports. Each end of the trough had roller guides so that the pipe rode these on its way through the tunnel, and

XUM



AIR VIEW of entire operation, showing pipe being conducted through sub-highway crossing. Note also pipe racks and seven caterpillar sidebooms.

was thence directed straight across the beach while the barge at sea pulled with three winches. Three 1¼-in. wire lines were bridled to the pulling sled on the front end of the line, and buoys were lashed to the front end of the pulling sled to give it a slight floating effect and so preclude the possibility of sanding up the line or nosing it into the ocean bed. When the pipe line was eventually in place, these buoys were cut loose by the divers.

As may be seen above the job site and working area was on the inland side of the highway and on ground that was considerably higher than the beach. The tramway and the right-of-way thus ran oceanwards in a cut that was about 12 ft deep.

All field joints were gunited except the 14 joints that linked the 270 ft sections. These were covered with an extra heavy coat of enamel and finally bound in heavy strips of canvas and a binder of 1-in. laths. As the cradle cars were emptied after each pull, they were drawn back to the loading area by a gasoline engine powered winch. The winch line also held a strain on the pipe while the points were being welded.

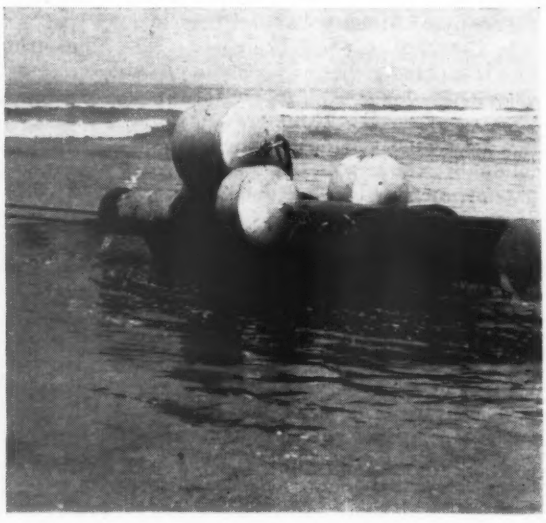
On the beach side of the tunnel, a deadman consisting of 36 yd of concrete was poured, and 1½-in. hairpins were inserted as emergency tie-downs in case of a rough sea. The entire job was so well planned and coordinated under the direction of G. W. Abernathy, president of Pacific Pipeline Construction Company, and B. L. Haviside, vice president and general manager of Haviside, that the total pulling operation was concluded in about 13 hr. This is believed to be record time for the laying of a submerged line of large diameter.

Credit should also be given to Bill Long, general superintendent of Pacific Pipeline Construction Company, and superintendent Ralph McFaul, through whose efforts the job was never behind time. It was finished, exactly as scheduled, on June 1, 1953, and every phase of the predetermined methods of operation went through without a hitch. It would appear that the mechanization of pipe line construction is keeping well up with progress in other departments of petroleum operation. The old days of threaded joints when brawn was more of a necessity than engineering skill are definitely gone. The army of ditch diggers, stabbers, tongmen, ropemen, barmen, jackmen, backfillers, and others who used to constitute a pipe line construction crew, has given way to a compact few who, with adequate equipment and engineering know-how, can do many times the work much more effectively.

Pipe line construction always has been, and still is, one of the more spectacular species of petrolic activity. For some reason, however, the pipe line people have been notoriously inarticulate, and it is only in the past decade that their exploits have been finding a place in the public print. It is merely necessary to take a look at the accompanying illustration to realize that jobs such as this must offer a challenge to construction engineers and that an accounting of the methods employed in the resolution of their problems should find wide interest. If variety is the spice of life, the pipe line constructors should be having a good time, for ordinarily, every job has its own grist of peculiarities to exercise engineering genius and develop engineering acumen. ★ ★ ★

TUNNEL UNDER highway showing trough and circulating water that was used to reduce friction. Handling ship-shore phone is Bill Long, president of Pacific Pipeline Construction Company.

FRONT END of line is just entering surf on a sled that is well buoyed to keep it from sinking far enough below surface to nose into the ocean bed.



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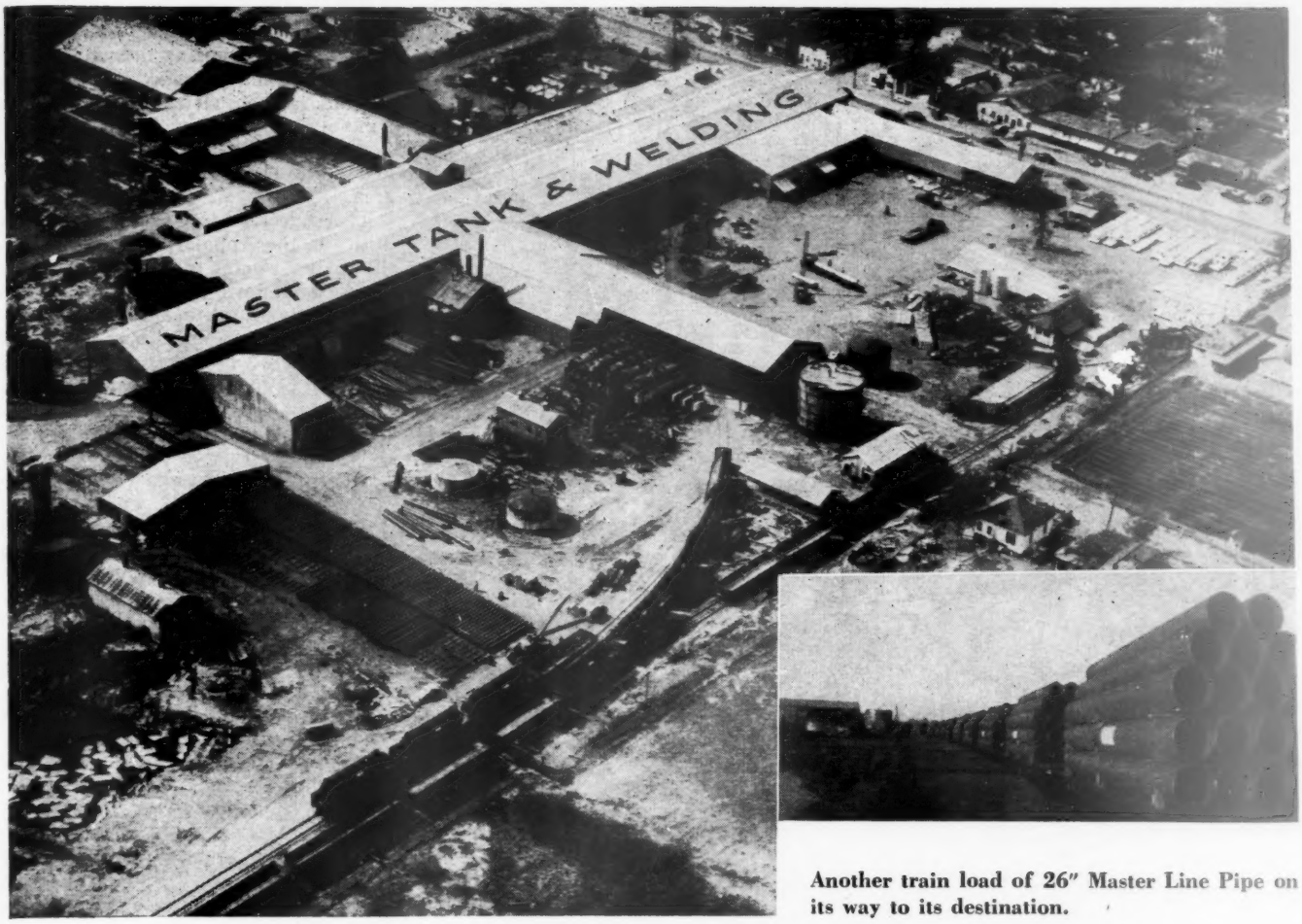

Another train load of 26" Master Line Pipe on its way to its destination.

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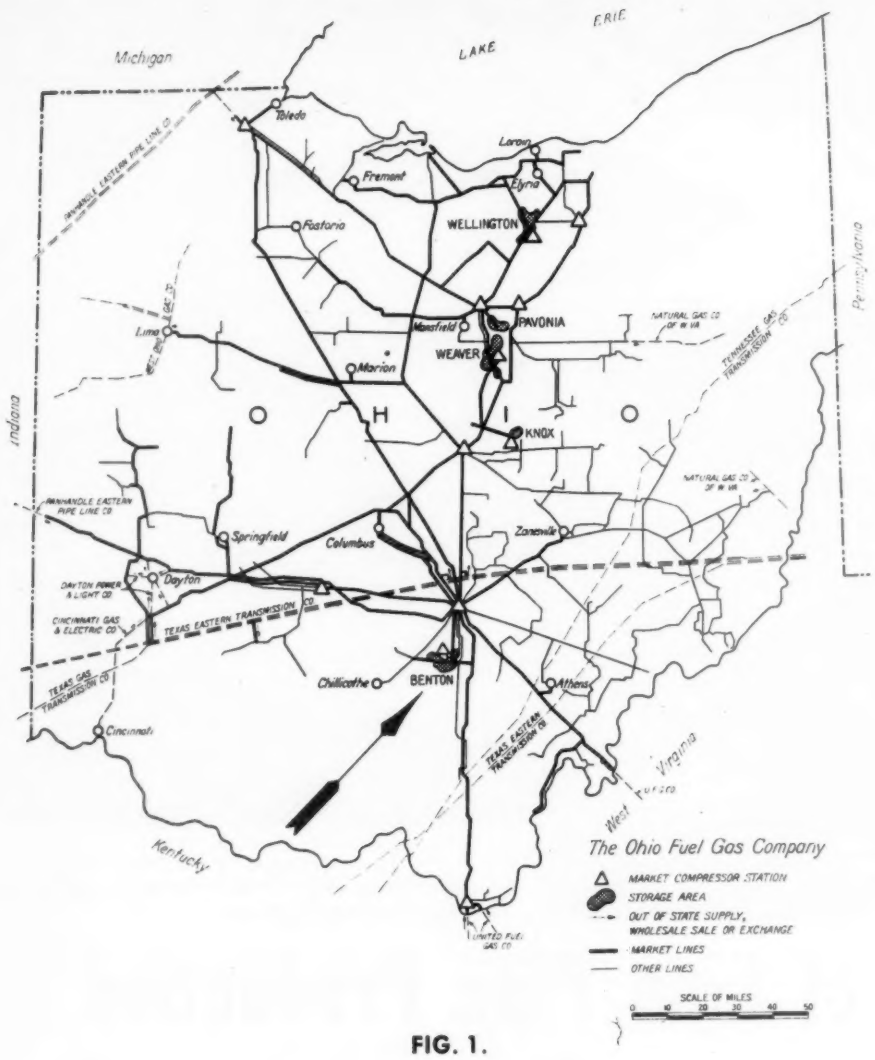


FIG. 1.

Development and Operation of an Underground Storage Program*

Details of the Benton project of The Ohio Fuel Gas Company, which is one of five

W. E. FERGUSON

THE storage of gas in underground reservoirs can be defined as the terminal operation in the temporary relocation of gas from the bin where nature placed it, to other more conveniently located storage bins, for the advantageous and beneficial use by man.

When we accepted the invitation to present a paper on storage we realized that it would not be necessary to dwell on the merits and advantages of underground storage, but we did conclude that it would be appropriate to preface our remarks with a few observations of some conditions, circumstances, and trends pertinent to this subject.

There is no question but that the gas industry has been and will continue to be confronted with the primary problem of developing and delivering increasing quantities of gas necessary to satisfy the requirements of a gas-hungry public, particularly during the winter heating season and on peak days. It goes without saying that this problem loses none of its complexity for the gas utilities operating in the densely populated and highly industrialized Appalachian area.

The Ohio Fuel Gas Company is a gas utility in the Appalachian area and, as this paper relates to its storage operations, some review of the extent and scope of its overall operations and obligations to its customers may be helpful in explaining why it has developed and gradually enlarged its storage program.

The Ohio Fuel Gas Company is a subsidiary of The Columbia Gas System, Inc., and operates exclusively in the state of Ohio. It is engaged in producing and purchasing local gas, the purchase of out-of-state gas, the storage of gas and in the transportation of gas to wholesale markets and in the distribution of gas to its own retail markets.

As of the end of 1952, through 6529 miles of transmission and field gathering lines, plus 281 miles of storage lines and through 6164 miles of distribution lines it retails gas in 361 towns and communities in 49 counties of the state. It also wholesales gas to 24 other utilities in Ohio.

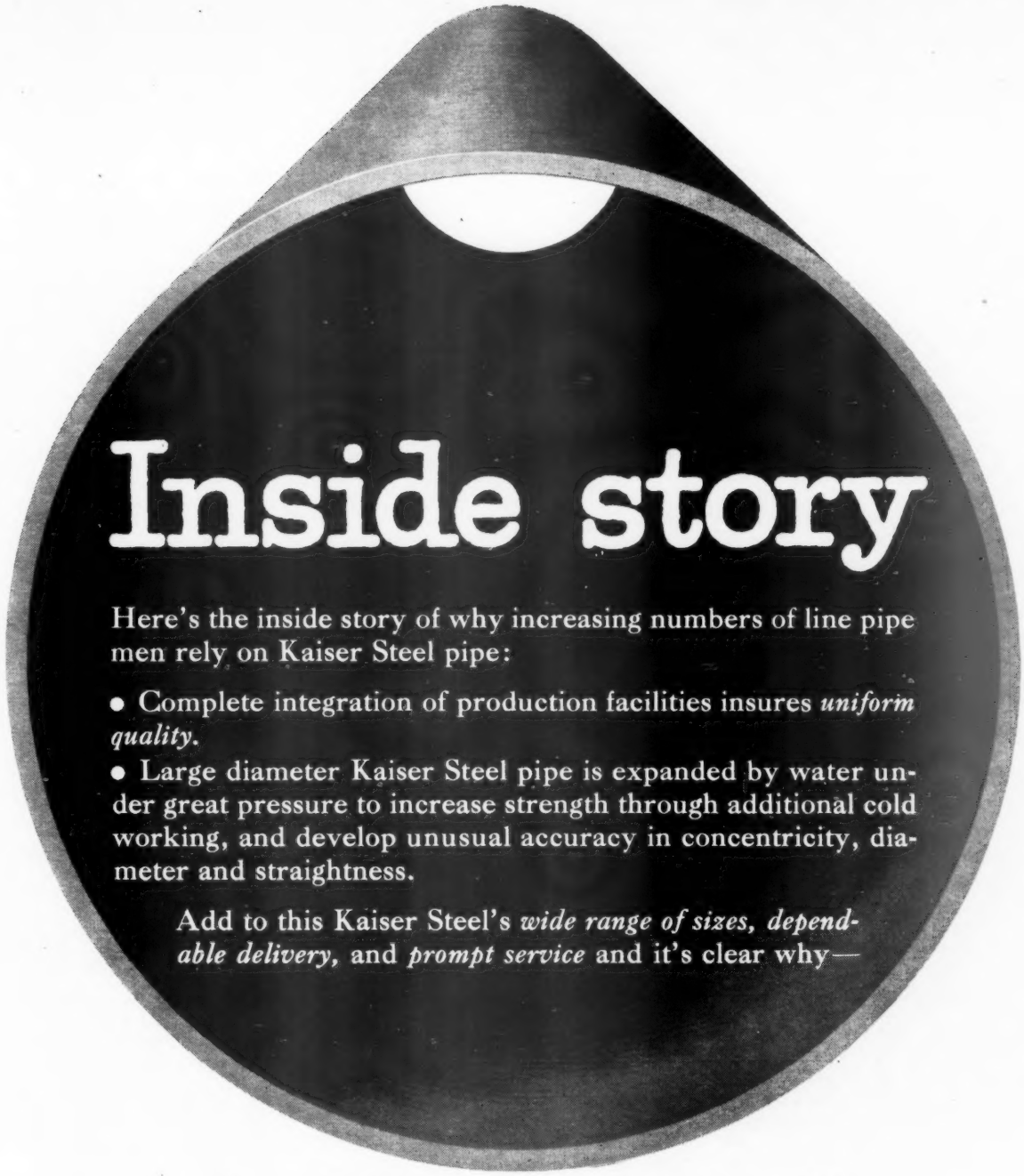
It operates 36 compressor stations with 63,435 total hp, with five such stations and 23,440 hp devoted exclusively to storage operation. It holds leases on more than 1,000,000 acres and operates 2349 wells for native gas production and 775 wells for the storage of gas. It purchases local gas from more than 2900 wells, owned by independent producers in Ohio and out-of-state gas from Panhandle Eastern Pipe Line Company, Texas Eastern Transmission Corporation and from Texas Gas Transmission Corporation. It also purchases gas from its affiliate, United Fuel Gas Company of Charleston, West Virginia, the major portion of gas available to United Fuel Gas Company being ob-

The Author

W. E. Ferguson, vice president of The Ohio Fuel Gas Company, in charge of its production and underground storage operations, has been actively identified with the natural gas utility industry since 1917. He became associated at that time with The Logan Gas Company, which he served successively as draftsman, chief draftsman, and chief engineer until 1929 when the Logan Gas Company was merged with The Ohio Fuel Gas Company.

Subsequent to such merger, he has served successively as chief draftsman, chief civil engineer, superintendent of the lease and engineering department, assistant manager, and manager of the production division.

*Presented before American Gas Association Transmission and Storage Conference, Chicago, Illinois, April 30-May 1, 1953.



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Continuous Weld—Threaded and Coupled	½" to 4" nominal I.D.	Uniform 21'	Standard	Fontana, Calif.
Continuous Weld—Plain End	2⅜" to 4½" O.D.	Up to 40'	Standard	Fontana, Calif.
Electric Resistance and Fusion Weld—Plain End	14" to 18" O.D.	Up to 40'	.250" to .500"	Napa, Calif.—Basalt-Kaiser
Electric Resistance Weld—Plain End	5⅛" to 12¾" O.D.	Up to 55'	.188" to .375"	Fontana, Calif.
Electric Fusion Weld—Expanded—Plain End	20" to 30" O.D.	Up to 40'	.250" to .500"	Napa, Calif.—Basalt-Kaiser

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tained from the Tennessee Gas Transmission Company.

The Ohio Fuel Gas Company supplies gas to 1280 industrial customers and through its retail and wholesale markets serve a total of over 775,000 customers of all classes.

During the last five years its total annual sales have increased from 92 to 155 billion cubic feet and its peak day sales, from 434,000,000 on February 5, 1947 to 1,017,000,000 on December 16, 1951.

Its house-heating saturation has increased from 22 per cent in 1947 to 61 per cent in 1952. On its peak day in February, 1947, 108,000,000 cu ft or 25 per cent of its requirements came from storage, as compared to 517,000,000 cu ft or 51 per cent on its peak day late in 1951.

While the normal growth and continued industrial expansion in the area served accounts for a portion of its increased sales, the disparity between the fuel costs of natural gas and that of the competitive fuels, coal and oil, has been the predominant factor in the rapid increase in its house-heating saturation.

A further complexity in the problem of meeting the resulting increasing requirements by gas utilities operating in the Appalachian area can be attributed to three other circumstances that are common to the area, i.e.

1. Wide seasonal temperature variations.
2. Insufficient new local gas developed to keep pace with increasing demands.
3. The obligation to accept the delivery of the gas purchased from out-of-state sources, on a firm schedule that permits the operation of the interstate gas pipe lines on a load factor approaching 100 per cent.

This brief resume of statistics and the conditions prevailing in the Appalachian area, plus the circumstances that contribute to the complexity of meeting the resulting market requirements in the area, all indicate why The Ohio Fuel Gas Company and other companies having some responsibility for serving the public in the area, have initiated and expanded their respective gas storage operations.

Each step in the development and operation of an underground storage project is perhaps equally important in assuring its successful operation and protection. The subject of this paper is so general and all-inclusive that we experienced some difficulty in the selection of the material that should be included. We consequently have limited our remarks to rather brief references to our storage operations generally, with a somewhat broader coverage of one of our projects, which has been in operation since 1936.

The storage project selected for review is one of five projects, all in the Clinton sand, now operated by The Ohio Fuel Gas Company. It is known as our Benton project, as it was initiated in Benton Township, Hocking County in southern Ohio.

The Benton project was selected because it represented an area well advanced in depletion which had produced relatively large quantities of native gas and was strategically located in relation to existing pipe lines, compressor power, and markets. It was activated in 1936 for the purpose of moving gas then produced within the Appalachian area, principally in West Virginia, to locations nearer our principal market requirements.

While the sequence of all the detailed steps involved in converting a depleted or semi-depleted native gas pool to storage operations may vary because of local conditions and circumstances, it is most essential that all negotiations for acquiring the rights necessary for both the operation and protection of each project be completed prior to the activation of any storage project. Such negotiations are, of course, preceded by the development of an accurate farm line map of the area and by the title checks necessary for such purpose.

Inasmuch as the Benton project represented our first venture in the underground storage of gas, it was naturally preceded by consideration from our legal department, particularly as to the form of agreement necessary to convey to us the rights for such operations.

We will not elaborate on all the many factors that contribute to the difficulties of making any project "ready" for storage, but can state from experience that the negotiations for all the rights required represent the most difficult and tedious step in a storage program, particularly in Ohio, where there is no statute permitting the appropriation of rights necessary for the underground storage of gas.

It has taken concentrated effort by competent experienced men to complete such negotiations under the circumstances that have prevailed in Ohio and we will merely state that those so engaged have done their job well.

Storage activation in the Benton project, and in others subsequently activated, was also preceded by careful study by our geological department. Maps indicating the sand thickness and form of the reservoir were developed, particularly as to the limits of probable migration of the gas and the perimeter of the project including a protective fringe area. Following these investigations, detailed calculations were made as to the volumes of gas that would be contained at varying reservoir pressures, as well as the rate at which gas could be injected or removed under changing conditions of reservoir pressure.

The Clinton sandstone, in which gas is stored in Benton project, is a hard, compact rock, the sand grains of which are almost entirely quartz cemented by calcium carbonate, and in those places where the rock is impervious, cemented frequently by silica. The rock is not a single layer, but a series of irregular, tapering lenses interbedded in shale. In some producing fields in Ohio, there are as many as five such lenses in a given locality, separated vertically by as little as 20 ft and difficult to correlate if such identification is done on the basis of vertical position only. In Benton storage no more than one Clinton sand body has been recognized in an individual well.

The maximum thickness of the reservoir at Benton is 25 ft, and the average about 10 ft. The average dip of the horizon in Benton is 67 ft per mile in the direction east-southeast. West of this storage area, and west of the producing belt generally, the Clinton sand is replaced by shale. Consequently, although the associated formations outcrop in southwestern Ohio, the Clinton sandstone nowhere reaches the surface.

The Clinton sand at Benton, in those fragments recovered in drilling, is a rigid, grey rock of average porosity, indistinguishable by ordinary inspection from many other producing rock samples taken from Appalachian wells. Both porosity and permeability range widely, even in such a limited area as that at Benton, though the porosity averages about 12 to 14 per cent, and the permeability appears to be of about the order of other Appalachian sands, somewhere between 50 and 100 md. The sand contains no water other than that of the sea it was originally deposited in, connate water in small amounts in the form of moisture between some of the sand grains.

Gas was discovered in the Clinton sand near Lancaster, Ohio, in 1887, and from that time to the present, this formation has been Ohio's most important source of local gas. Clinton pools vary in size because they are related directly to the geological lenses forming the individual reservoirs. The present eight individual storage sub-projects at Benton are typical of the smaller Clinton pools. As a matter of fact, they are old pools from which most of the original or native gas had been removed when underground storage began.

The existing producing wells in areas to be converted to storage are of course inspected and rehabilitated prior to the activation of the project. Without elaborating on this detail, the wellhead fittings and valves are replaced with 1500 psi test equipment and as these wells are equipped with 2-in. or 3-in. tubing run on a packer, all tubing and casing unsuitable for storage operations is replaced.

The new wells drilled for storage are completed with the 5 3/16-in. pipe serving as the production string. In the Benton project our new wells are equipped with 8-in. through the surface water, with 6⅝-in. through the Berea sand and with 5 3/16-in. cemented just above the Clinton horizon. To effect a good seal at this point we run 5 to 7 sacks of Aqua-Gel, following with 30 sacks of cement, which is allowed to set for 72 hours before drilling the well in.

All storage wells are normally left on line after being connected to the storage pipe line system in each sub-project, so that gas may be either injected or withdrawn by operating the valves at the sub-project meter at the storage compressor station.

Our well tenders observe and report

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regularly the minute pressures at each storage well, during both input and output, so that the rate each well takes and delivers storage gas under varying pressure conditions can be determined.

In designing and constructing a pipe line system for gas storage input and withdrawal, numerous factors must be considered, such as maximum storage input pressure, maximum day deliverability, the location and initial volume of the present wells, as well as the location and potential volume of those additional wells to be drilled in the future. With these factors all in mind it is possible to lay out the most economical pipe line system, sizing the lines so that the desired minimum pressure drop from the wellhead to the transmission system can be maintained.

Pipe and valves are selected and installed according to the best practice of the industry and in agreement with the latest approved codes and standards.

Most of the soils in Ohio require coating to protect the pipe against underground corrosion. Drips are installed in connection with every well and on the gathering lines themselves to assist in the removal of any liquids.

Our storage compressor station at Benton consists of nine engines with 2490 total hp and gas is stored in this project at a maximum pressure of 800 psi. With gas being delivered to Benton station at 450 to 500-psi pressure, this station can handle, depending on intake and project pressures, from 45,000,000 to 65,000,000 cu ft a day during input operations.

The measurement of the gas to and from storage as well as accounting for the gas lost and used in the operation of storage, is of vital importance to those engaged in these operations, and particularly to public utilities, which are obliged to maintain records in sufficient detail to satisfy various audits and regulatory requirements.

The Ohio Fuel Gas Company maintains a record of the gas in storage on a continuous inventory basis. The gas is metered in and out of storage by orifice meters installed adjacent to our storage compressor stations. Such measurement consists of a series of parallel runs, two or more of which are usually 6-in. or 8-in. for output, to accommodate volume requirements as needed. The meter runs for input are 3-in. or larger, being sized as small as possible to handle input volumes, with the smaller runs together with other mitigating equipment both serving to eliminate the effect of pulsation on measurement.

Each sub-project is equipped with such a measurement installation and the excess of input over output during any period constitutes the net gas placed in storage, subject, however, to an adjustment for the gas lost and used from storage in each sub-project during such period, some of which gas is metered and some calculated.

The gas lost and used can be divided into three general classifications for accounting purposes as follows:

1. Chargeable to operation expense:

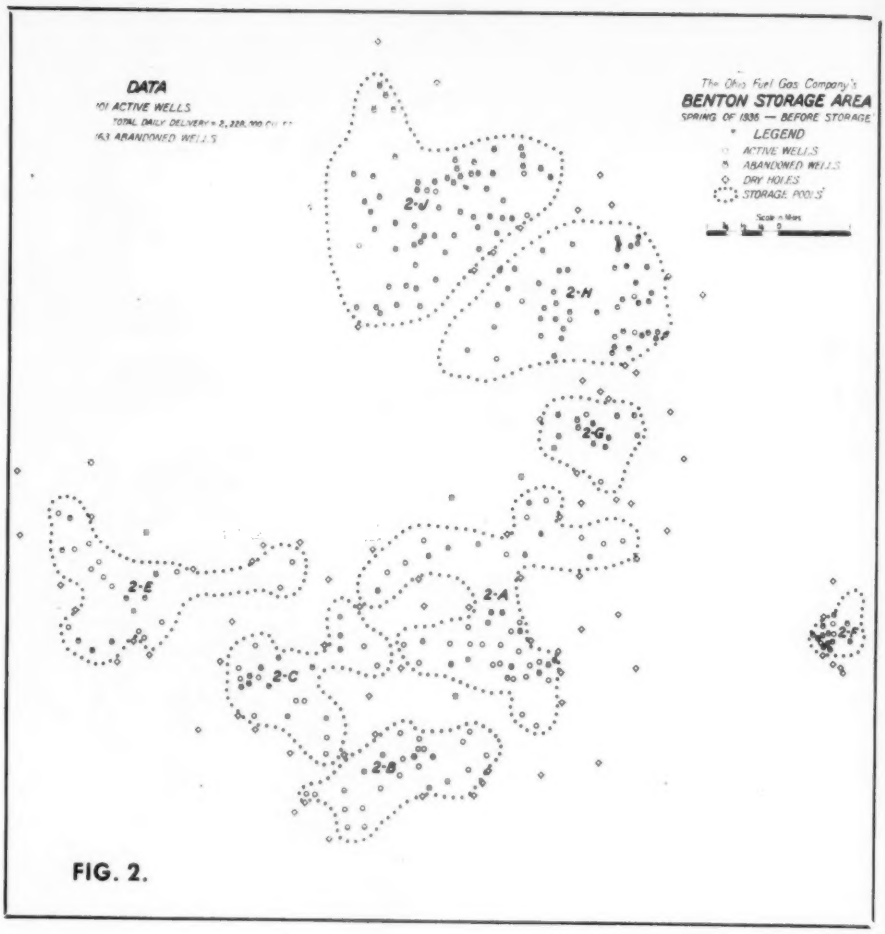

FIG. 2.

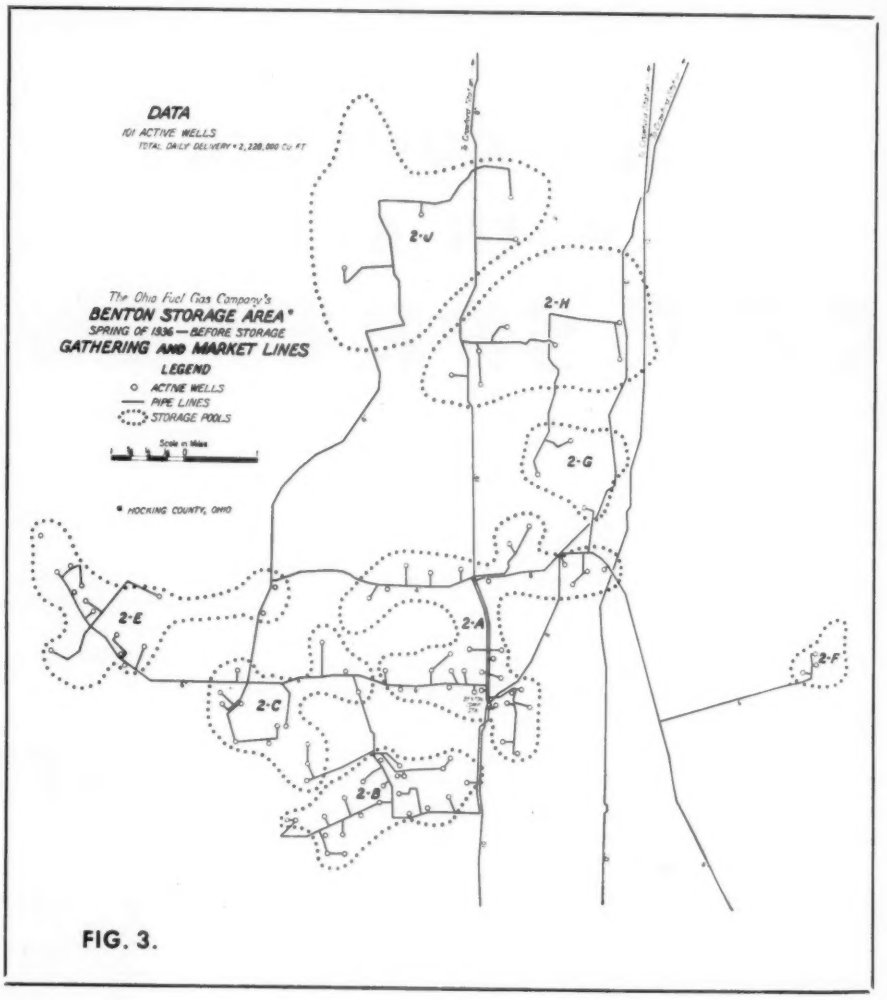

FIG. 3.

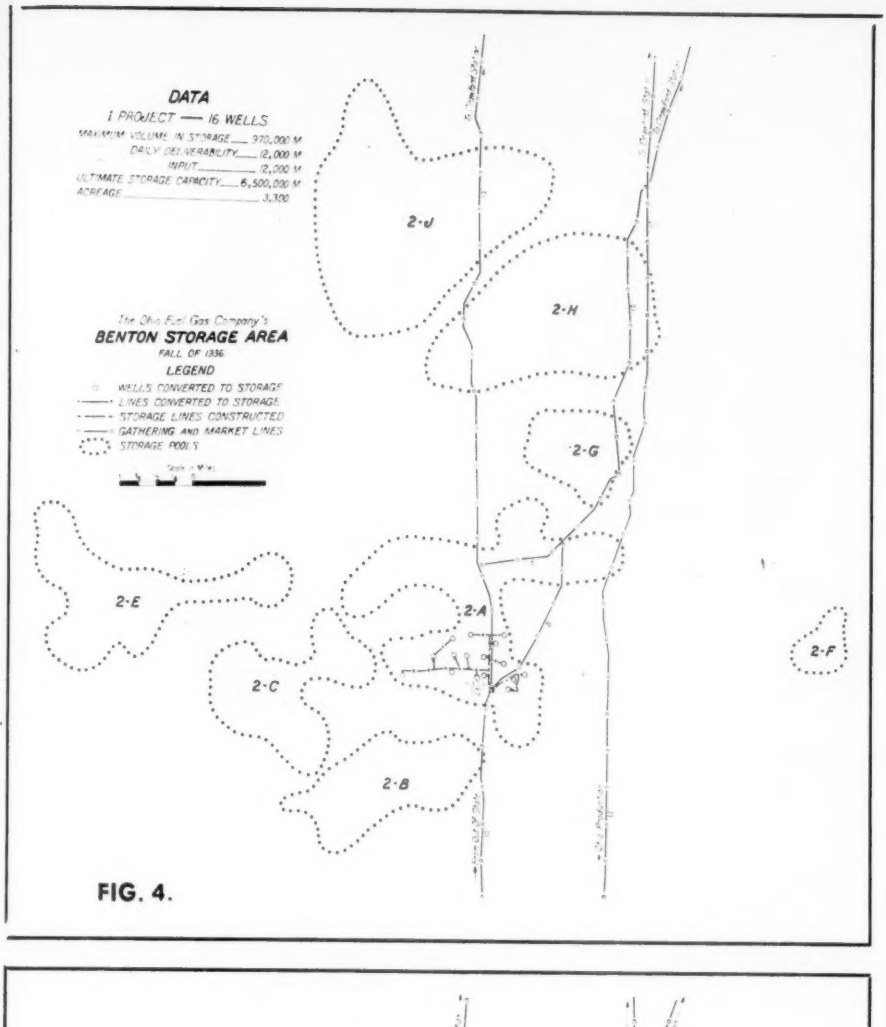

FIG. 4.

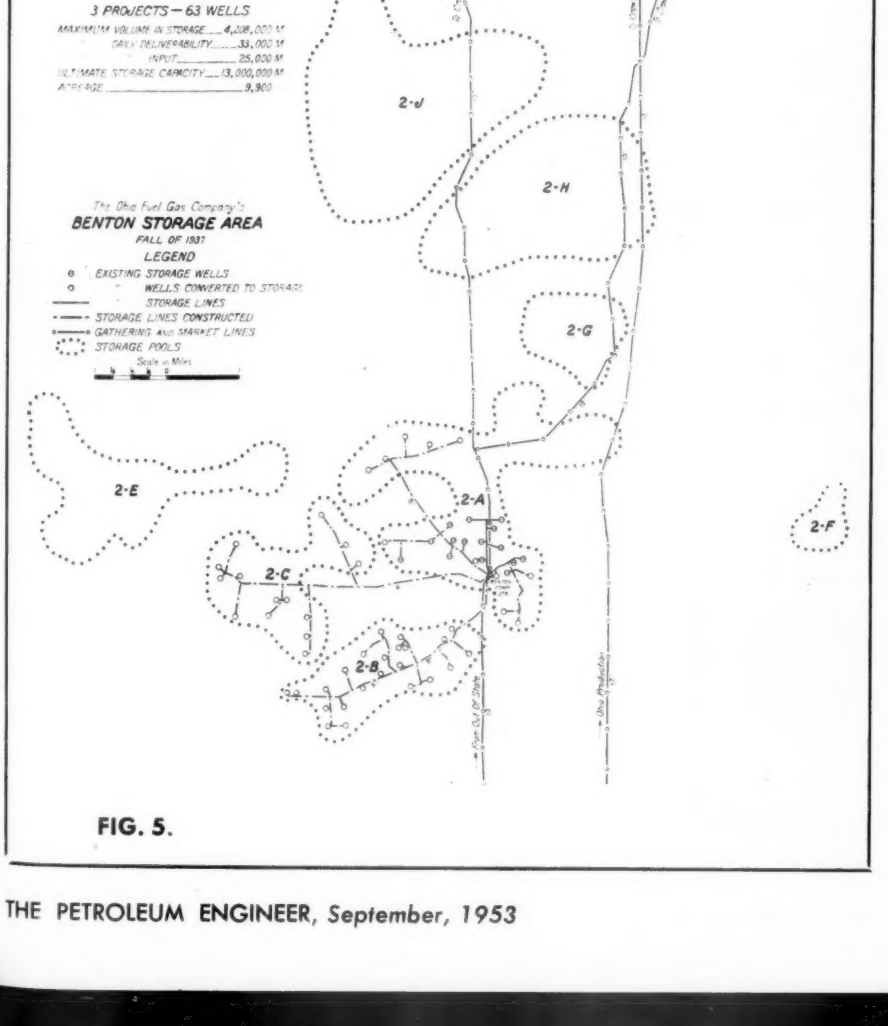

FIG. 5.

a. Loss due to leakage and line purging (calculated)
b. Loss due to blowing drips and wells (calculated)
c. Loss due to well repairs (calculated)
d. Used for fuel during well repairs (metered)
e. Used by free consumers (metered)

2. Chargeable to capital accounts:
   a. Lost in drilling in new wells (calculated)
   b. Used as fuel for drilling new wells (metered)
3. Chargeable to revenue:
   a. Used by rural pay consumers (metered)
   b. Produced into non-storage lines (metered)

The term "loss and use" consequently represents an adjustment of the total gas in storage and since the metered and calculated volumes involved are all either legitimate items of expense, capitalized or sold, the term "loss and use" does not indicate financial loss. It has been our experience that the total volume of gas involved in our loss and use adjustments represents about one-half of one per cent of our annual turn-over of stored gas.

As storage operations have been expanded and considerable publicity given to this subject, questions are naturally asked about storage, the most common inquiries being about as follows:

How do you know the gas you claim you have in storage is there?

How do you know you will get it all back?

How much do you lose in the ground?

We maintain that there can be no loss of gas placed in storage, until it makes its way to the surface and is there produced or released to the atmosphere. If the gas is contained and the right to recover the gas is controlled by the operator of the project and if the loss and use of the gas after it is metered in and before it is metered out of storage is properly accounted for, it follows that the gas in storage at any time can be accurately computed.

The lateral, or for that matter even vertical, migration away from the well bore does not result in loss of gas, if no one else can recover it, as a reversal of differential pressure will revert such migration back to the well. There can be no appreciable vertical loss, for attention is again directed to the fact that the older storage wells at Benton are packed 30 ft or so above the Clinton sand, while the newer wells contain casing cemented on or immediately above the Clinton. The gas is thus confined entirely to the Clinton zone, in which any interbedded shales are practically impervious, and all formations above the Clinton zone of sandstone and shale are excluded.

Thus, by adequate protective leasing and a close observation and reporting of the so-called "loss and use" volumes, the operators of the project can state with confidence that the resulting total volume in storage is an accurate statement of fact.

Another question frequently asked is

the number of storage wells required for most efficient operation. There is no ready answer for this because of the many variables involved. Our storage wells are used for both input and output. Serious thought must be given to having sufficient wells for deliverability, both for rates of input as well as for output. In a part of the reservoir where the rock is thick, of greatest porosity and most favorable permeability, a minimum of wells might be required. In another part of the same reservoir, where the other factors are on a par with the first example but where the factor of permeability is low, it is often necessary to have more wells. Ordinarily, producing wells are spaced with the purpose of removing the maximum of production with the minimum of well cost, so that the cost economics becomes a matter of dividing the drilling cost by the units of reserves to be recovered as a result of the drilling. Much of the same economics applies to the storage well with one notable difference.

The main purpose of underground storage is to have gas supplies available for seasonal demand, for the requirements of the cold months, or the cold days, or the cold hours when the need is urgent. Consequently, rate of delivery is most important. With insufficient wells in an otherwise ideal reservoir gas cannot be removed rapidly enough to supply consumer demands, so that the proper number of wells must be drilled to withdraw gas at the rate required.

The same reasoning applies to input. In mild winters, it may be possible to store gas on an occasional warmer day, but such volumes are usually of little consequence. Generally, winter output must be planned on volume scheduled and stored during the preceding summer period. Accordingly, the equivalent volume removed in the winter must be stored in approximately 180 days between spring and fall, and, just as in planning the capacity of a transmission line, sufficient well capacities must be planned to transmit volumes at the rate required.

In making plans for total volume to be stored, it is assumed that the peak daily requirement from storage will occur on or about February 1. Probably the most important feature in planning the daily rate during the input cycle is the objective of having sufficient volume in storage to yield required deliverability for the peak day of the following winter. It is likely that consumer demand may call for considerable volumes from storage as early as December 1, and possibly for many days between that date and the first of February. Nevertheless, in order to plan, as far as possible, that a shortage may not occur during the winter, February 1 is assumed to be the date of required peak output from storage.

Normally, maximum deliverability from storage occurs at the beginning of output cycle, when the maximum volume of stored gas is contained in the reservoir at maximum pressure. The theoretical rate of initial output in the fall almost always exceeds the actual

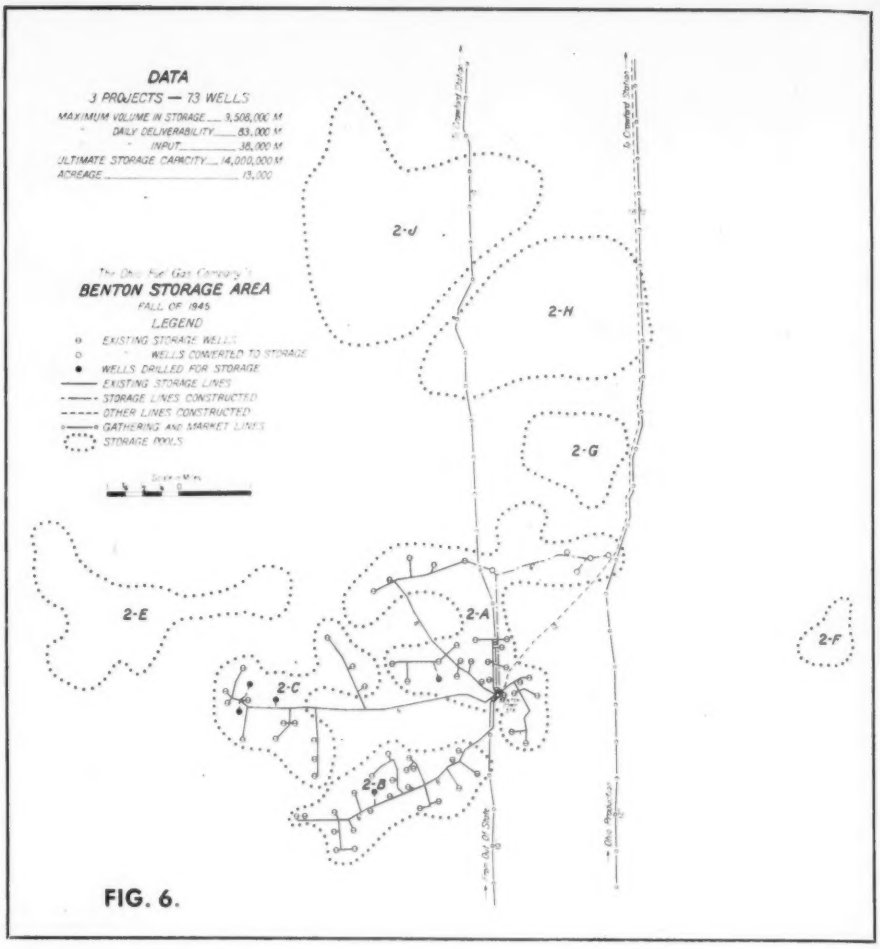

FIG. 6.

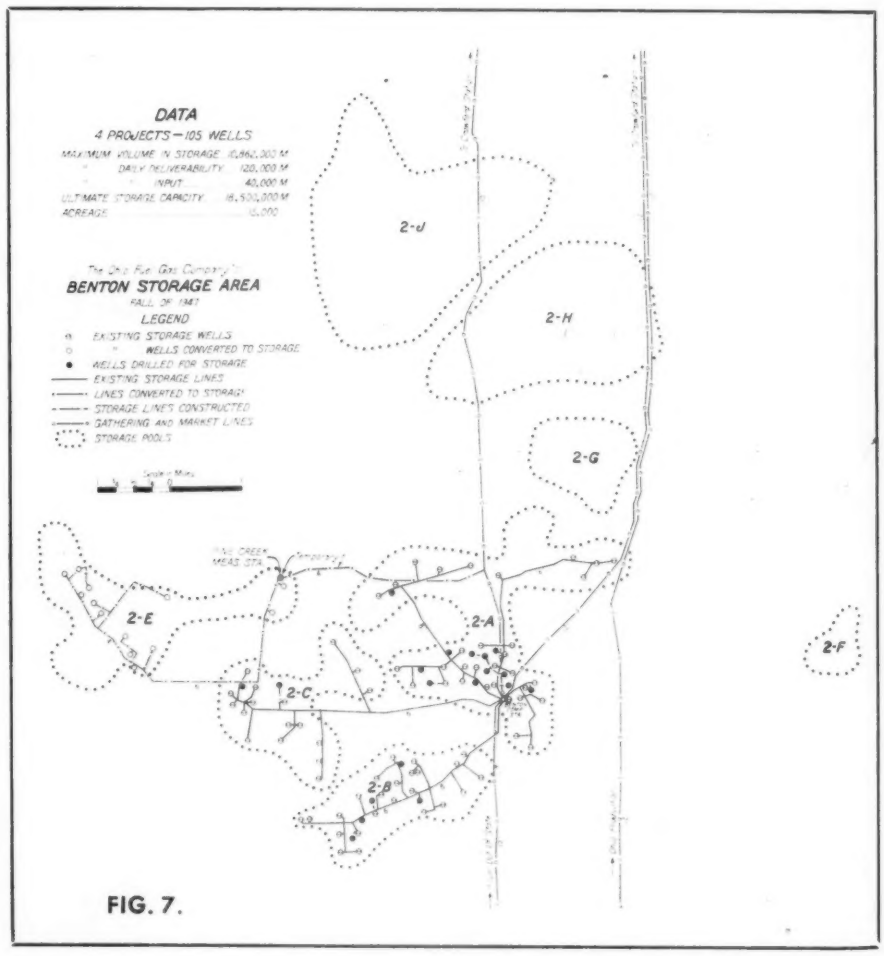

FIG. 7.

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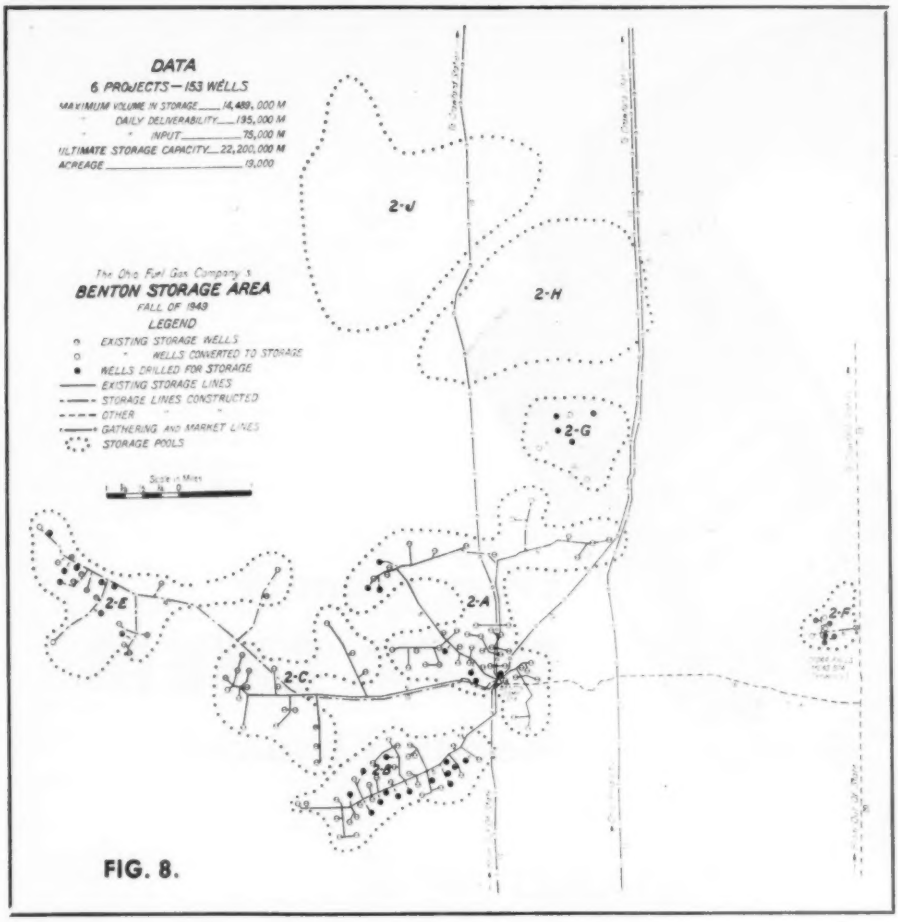


FIG. 8.

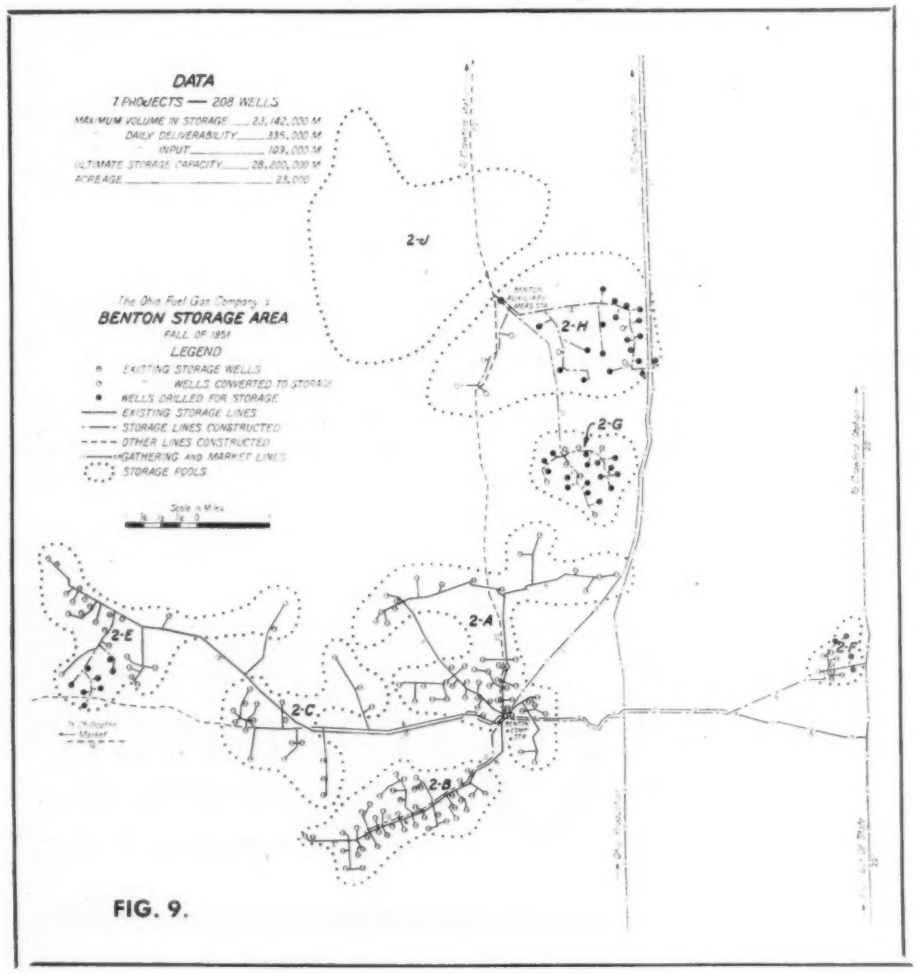


FIG. 9.

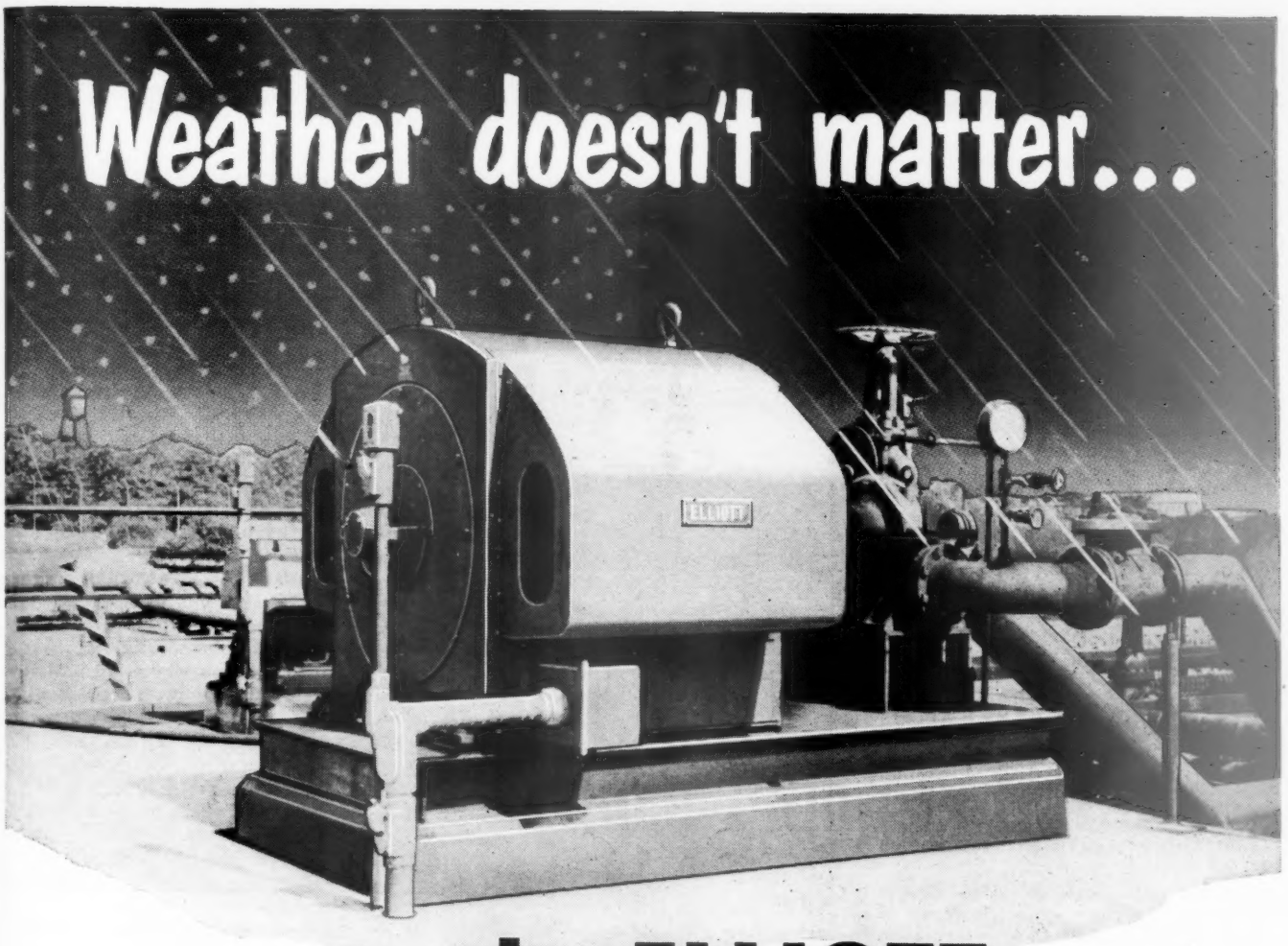
rate because of line capacities, for obviously lines cannot be built for maximum delivery because of prohibitive cost. During initial output in the fall, when reservoir pressure is high, gas may not be pumped but bypasses the compressor. In any event, as gas is withdrawn from storage and the remaining volume diminishes, reservoir pressure diminishes, accordingly. The fact is sometimes overlooked that decline in daily delivery is quite considerably greater than decline in stored volume. Because of fundamentals governing the flow of gas from a reservoir, deliverability is not directly proportional to stored volume throughout the output cycle. The decline in deliverability is more rapid than decline in stored volume, and it is not unusual, when half the gas has been removed and the decline in stored volume is, let us say, 50 per cent, to find that the decline in deliverability approximates 70 per cent, or that the rate of delivery is only 30 per cent of that initially in the fall.

Another question sometimes asked is that concerning the seasonal volume of stored gas turnover. Any answer to this question is likewise modified by conditions, both in the reservoir and from the standpoint of the market. A company having several underground reservoirs usually finds that one is adapated to short-period and large volume deliveries, where another is more suitable for longer demand periods. The first may have a greater rate of production over short intervals whereas the second may produce at lesser rates but with less decline in delivery volume. Sometimes, because of geographic location or the relation of facilities or markets, a given reservoir may be held for short peaks, whereas another, perhaps of its size, may be used for volume storage and longer output utilization. In case there are several reservoirs, it will be found that each has its pattern of behavior, and the way it is used will be adapted to that pattern.

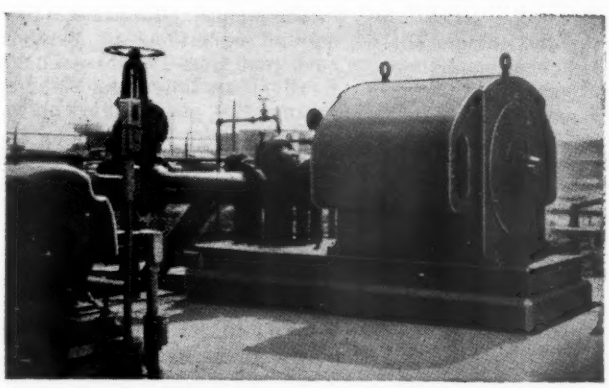
In general it can be said that with certain restrictions, the greater the turnover the better will be results from the economic viewpoint. However, there are practical limits to the volume that can be moved in a season. Uusually, there is an operating cushion made up of native and stored gas below which, or even approaching closely to which, storage will not function effectively. On the other hand, the upper level of capacity is limited by operating factors, of which the ultimate storage pressure is probably most important. One project at Benton has experienced as much as 60 per cent turnover in one season—a removal during the winter of 60 per cent of the total volume in storage at the beginning of output in the preceding fall.

The Benton project, in its entirety, has not been fully developed because of newer and more recently added subprojects. However, in the planning of schedules, we have thought of 40 per cent winter turnover as being practical. This would mean that about 40 per cent of that volume held in storage on or

Weather doesn't matter...



...to the ELLIOTT OUTDOOR SPLASHPROOF MOTOR!



Top picture: Elliott 250 hp. outdoor motor driving pump in a refinery, exposed to the battering winter storms sweeping across three thousand miles of the North Atlantic.
Just above: Another view of the installation, showing also, at left, a smaller Elliott Crocker-Wheeler motor.

© Howling blizzard, sleet, tropical deluge, fog, salt spray, dust-storm — none of them have anything to say to this tailored-to-the-job Elliott "Fabri-Steel" squirrel-cage induction motor, shown in the photo above driving a pump for an important northeastern oil refinery. This motor saves three ways — (1) makes housing unnecessary — (2) makes special vented foundation unnecessary, needing only a simple slab — (3) makes awkward piping layout unnecessary, since you can put it just where you want it, regardless of cover.

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about November 1 would be removed during the following winter heating season.

The total gas involved in storage operations is composed of three units of gas, namely:

1. Native gas. The gas in the reservoir at the time of its conversion to storage operations; and
2. Cushion gas. The volume of gas injected after conversion which, in addition to native gas present, will result in sufficient reservoir pressure to give operating efficiency from the reservoir; and
3. The gas available for market.

The native and cushion gas both remain in the reservoir through the life of the project and serve as a source of "free power" in the recovery of the gas available for market. Both native and cushion gas in storage can be ultimately recovered should the operation of the project be concluded.

It is estimated that we have a total of about 25⅓ billion cubic feet of native gas in all our projects, with 1¾ billion at Benton, which was activated for storage operation at a time when the area was well advanced in depletion. Native gas appears in no statistics relating to our gas in storage.

As of December 31, 1952, 40 billion cu ft of our total gas stored was classified and capitalized as cushion gas, of which 13 billion cubic feet was cushion for our Benton project.

It was our conclusion that in the presentation of our subject, a series of maps and schematic drawings portraying our Benton project, in various stages of its development, would prove interesting to this group.

The first of such maps (see Fig. 1) is a map of Ohio, indicating the location of our five presently operated storage projects in relation to our major pipe line network, market compressor stations, our principal wholesale and retail markets and our sources of out-of-state gas.

The next schematic map (Fig. 2) reflects the 101 producing wells, the 163 abandoned wells, and the dry holes in the Benton project, plus the perimeter of each sub-project, as existed in the spring of 1936, just preceding storage operations at this location. The numeral "2" indicates the storage project number and the letters suffixed to the numeral "2," the identification of each sub-project, assigned in the sequence activated.

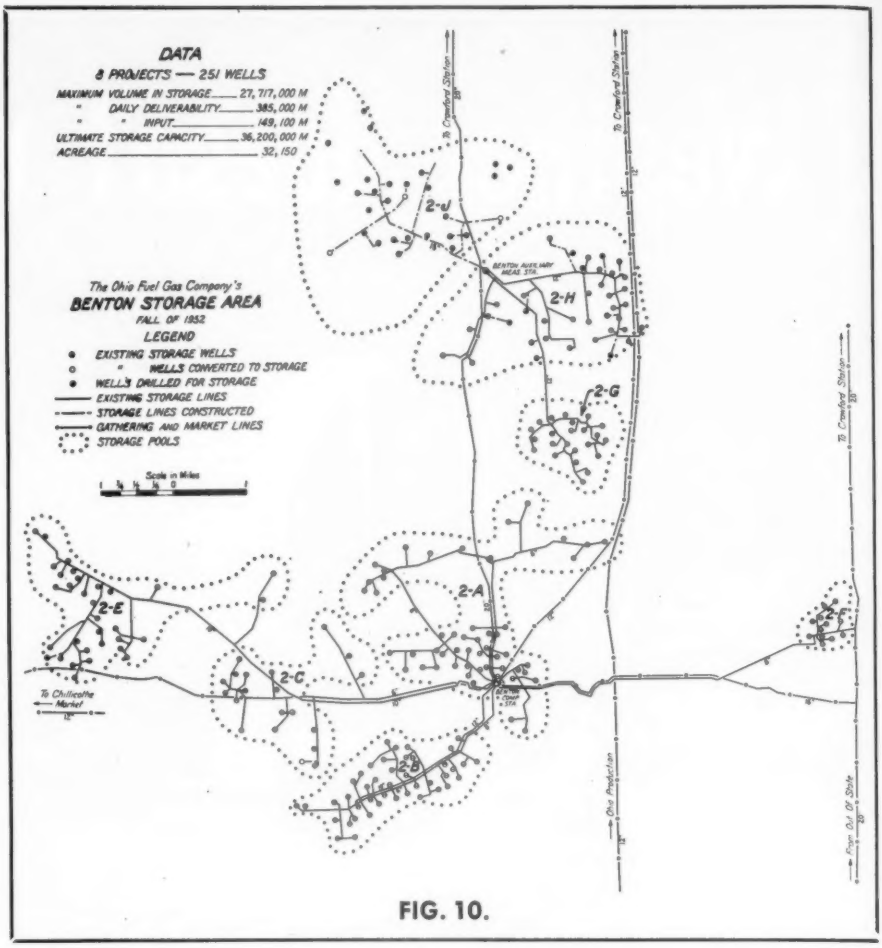


FIG. 10.

The next map (Fig. 3) reflects our pipe lines and active wells in the Benton area as they existed in the spring of 1936, just preceding the activation of the first sub-project for storage. This local production was then being handled by our Benton compressor station and the total daily delivery of 2,225,000 from the 101 active wells emphasizes that the pools were well advanced in depletion.

The next seven schematic maps (Figs. 4 through 10) and the data appearing thereon, graphically portray the gradual development of our Benton project.

These seven maps indicate the sub-projects activated, the number of wells utilized for storage, the acreage involved, and related storage statistics for this project as of about November 1 of the years 1936, 1937, 1945, 1947, 1949, 1951, and 1952.

The summary in Table 1 reflects our storage operations at Benton during each year from 1936 through 1952. The total volume stored and withdrawn represents the gas handled during each calendar year.

The maximum volume in storage, the maximum daily deliverability and the maximum actual daily output may have occurred in the calendar year, or the early part of the year following, depending on the weather, etc.

You will note that there appear to be some inconsistencies in the relationship between maximum volume in storage and maximum daily deliverability, which is attributable to the spread of the volumes stored in the various sub-projects. In any year during which storage is being enlarged or expanded, the injection of relatively large volumes used in building up a new project will not be reflected immediately in deliverability. Furthermore, the deliverability in any developing storage project is affected to a great degree by the quantity of native gas remaining, so that delivery rate and stored volume preceding the delivery are not necessarily proportional.

It may be of special interest to note

TABLE 1. Benton Storage,
Volumes and number of wells—Annual (M cu ft)

Year	Volume stored	Volume withdrawn	Max. volume in storage	Max. daily deliverability	Actual max. daily output	Date	No. of wells
1936.....	956,623	11,281	969,424	12,000	11,567	1/11/37	16
1937.....	3,874,774	862,792	4,207,613	33,000	27,816	12/ 9/37	63
1938.....	3,271,951	1,711,798	5,920,804	45,000	31,942	12/27/38	63
1939.....	2,340,317	3,010,330	6,023,779	48,000	33,909	12/ 7/39	63
1940.....	3,925,698	1,885,586	6,907,521	62,000	34,962	1/20/41	63
1941.....	3,704,486	2,467,345	8,193,283	56,000	50,446	1/ 8/42	63
1942.....	3,330,487	3,989,145	8,740,569	73,000	60,623	12/ 2/42	63
1943.....	3,510,355	3,517,445	8,488,605	70,000	56,594	12/16/43	68
1944.....	3,534,116	3,844,072	8,891,842	76,000	59,011	11/30/44	69
1945.....	4,535,922	3,097,750	9,508,444	83,000	65,426	12/17/45	73
1946.....	4,026,111	3,981,661	9,853,325	87,000	67,282	12/ 2/46	73
1947.....	5,204,907	5,422,051	10,862,204	120,000	83,831	11/25/47	105
1948.....	6,611,521	3,871,508	11,976,001	140,000	77,527	1/30/49	125
1949.....	6,420,378	3,968,117	14,489,125	195,000	85,325	2/15/50	153
1950.....	8,788,222	8,078,653	17,857,210	250,000	118,724	12/18/50	171
1951.....	13,210,274	6,969,622	23,142,351	335,000	168,001	12/16/51	208
1952.....	13,192,881	9,034,688	27,717,190	385,000	154,953	1/ 6/53	251
	90,439,023	65,723,844					

Volume in 12/31/52 — 24,715,179

that at our Benton project, up to December 31, 1952, we had stored since 1936 a total of 90½ billion and withdrew 65¾ billion cubic feet of gas. At the time the various sub-projects were activated the average reservoir pressure at Benton was 72 psi and by storing gas at a maximum pressure of 800 psi, that as of the end of our 1952 input season, the reservoir pressure in the various sub-projects had increased to from 534 psi to 778 psi.

In all our storage operations up to December 31, 1952, including four other projects, where gas has been stored at a maximum pressure up to 1100 psi, we have stored a total of 233.8 billion and withdrew 146 billion cubic feet of gas, ending up the year 1952 with 87.8 billion cubic feet in storage.

In our storage operation in the Clinton sand in Ohio, we have not to date been faced with problems or complications arising by reason of improperly plugged holes, by coal operations or by water in the storage horizon. We are aware that any of these things can complicate the development and operation of storage projects and add to the cost thereof. In our opinion the lenticular Clinton sand in Ohio provides an almost ideal natural reservoir for the storage of gas.

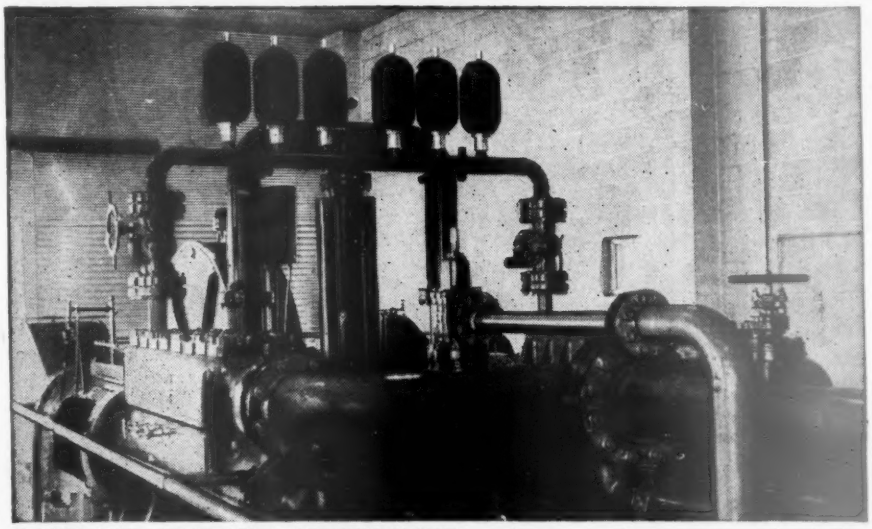
Although our storage operations at Benton were initiated on a rather modest basis in 1936 as an expedient for meeting a then existing system situation, later developments brought underground storage to a place of prime importance. The technique of longer high-pressure lines, particularly new welding practices, has made large volumes of gas produced in the Southwest available to Eastern markets, where the local supply has diminished and where the demand has grown tremendously. Benton and our other storage projects as subsequently developed became a necessity for our survival as a public utility, if we were to meet not only peak day, but winter volume requirements of our markets. Storage is, in our opinion, the only sound economical and practical means available to the gas industry to balance present market demands with the gas available from all sources and under conditions prevailing in the Appalachian area.

As some evidence of the importance of storage to The Ohio Gas Company, not only for the present but for the future, it had invested as of December 31, 1952, over 25⅓ millions of dollars or 13¾ per cent of its total plant investment in over 101,000 acres of land and leaseholds and in wells, lines, compressors, meters, structures, and in cushion gas, all devoted exclusively to the operation and protection of its underground storage program.

As mentioned early in this paper, it has not been possible to more than touch upon the many phases of a subject so broad and all-inclusive as the subject assigned to us. In our judgment, every phase of underground storage is important and would provide adequate material for an interesting paper.

* * *

GREER TOPICS **Functions and Applications of the Greer Accumulator**



PORTLAND PIPELINE CORPORATION engineers no longer worry about the problem of pump pulsations since Greer accumulators were installed on their equipment. Pressure surges from reciprocating pumps were rendered harmless. See below.

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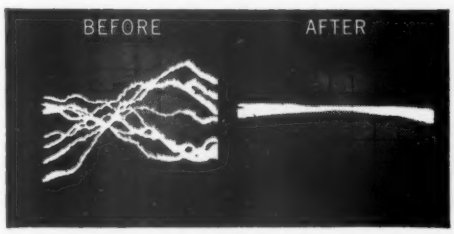

PROOF POSITIVE! Hydrauliscope photographs, taken before and after the installation of Greer accumulators, give conclusive evidence that pump pulsations were reduced more than 67% for Portland Pipeline pumping equipment. Write or call Greer now for special Bulletin 500 that gives complete technical data and diagrams on pump pulsation problems and corrections.

Actual hydrauliscope tests prove pressure surges can be reduced as much as 90%

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This compact power package, with its unmatched ability to absorb shock, renders pump pulsations harmless. The result is a smooth, steady flow of fluid so vital to efficient hydraulic operation.

Are you troubled with a pump pulsation problem? Then let our experienced hydraulic engineers demonstrate how costly downtime can be avoided, how performance and production can be improved, how equipment can be given longer life with the installation of a Greer accumulator. Write or call today.

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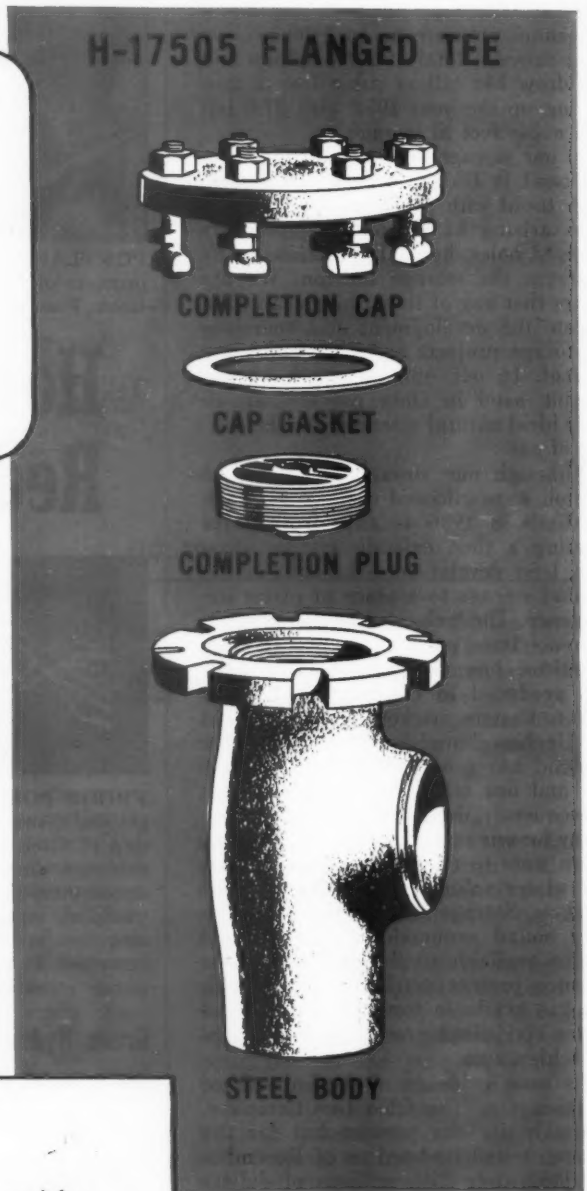

Mueller Flanged Tees are specifically designed for use when it is desirable to run a lateral or make large main connections. They may be installed in a minimum excavation, saving both time and expense.

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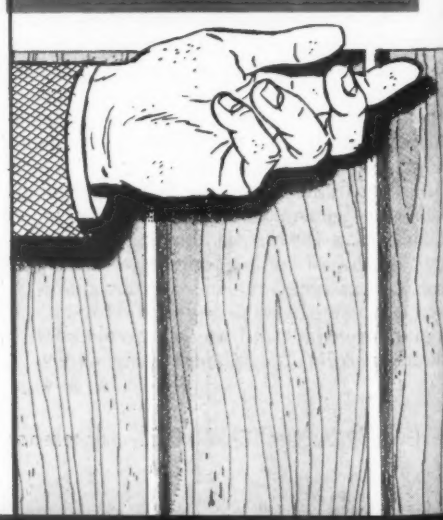
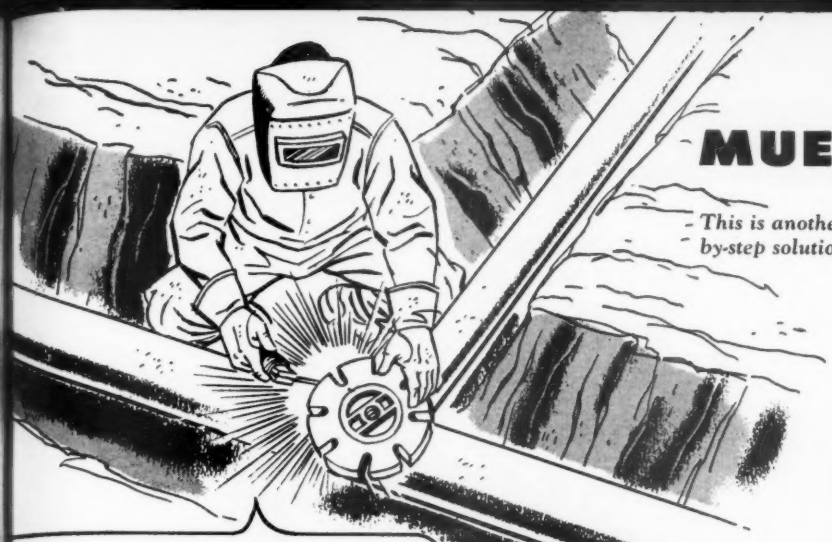


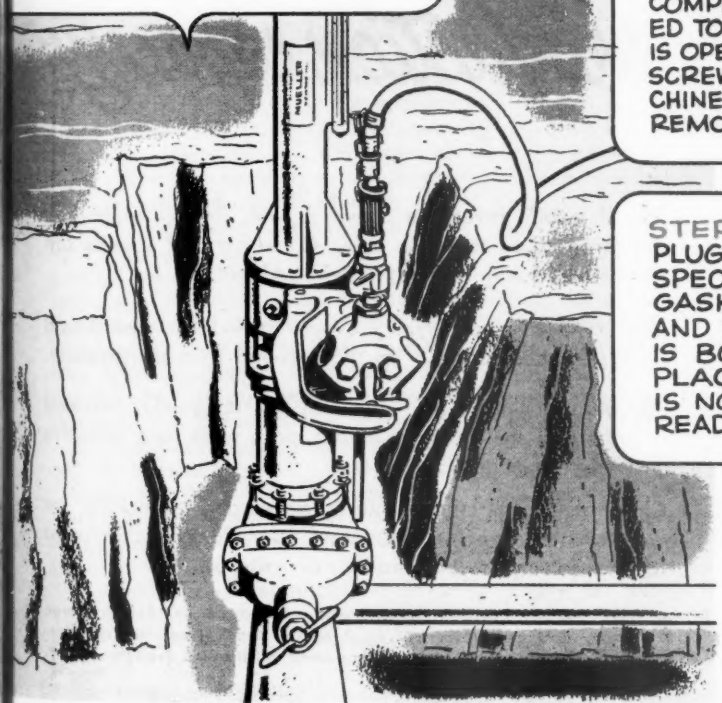
MUELLER NO-BLO Method

This is another of a series of gas distribution problems and their step-by-step solution by Frank Miller, Gas Service Engineer of Mueller Co.

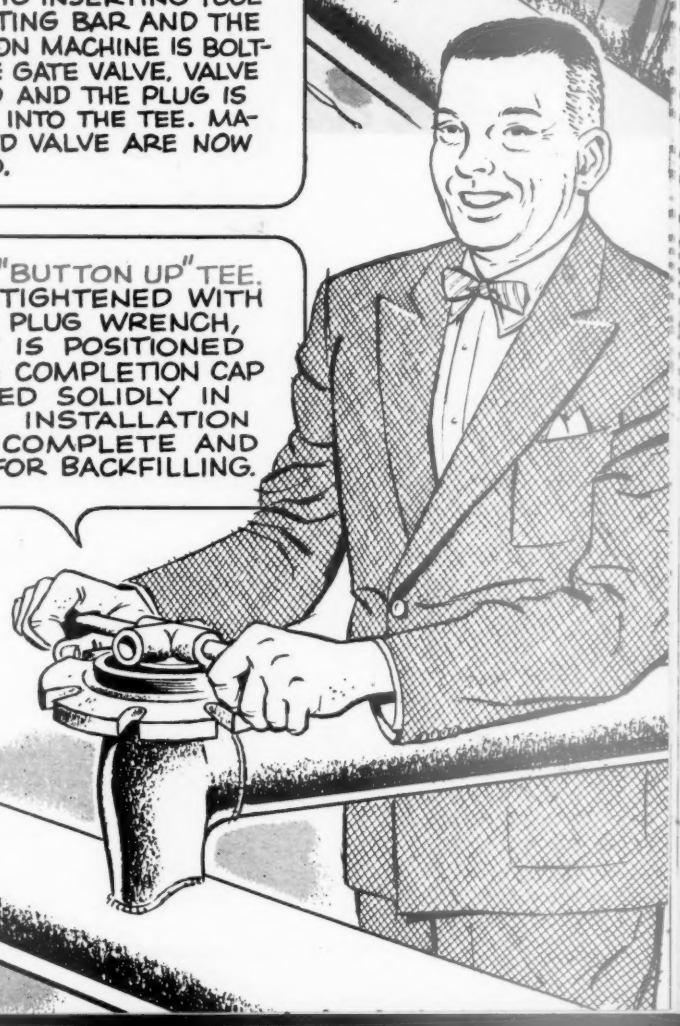


STEP 1. WELD TEE TO MAIN. COMPLETION PLUG SHOULD REMAIN IN TEE — HAND-TIGHT — DURING WELDING. NEW LATERAL IS WELDED TO OUTLET AND COMPLETED AT THIS TIME. ALLOW TEE AND LINE TO COOL NATURALLY. THEN, BOLT MUELLER GATE VALVE TO FLANGE OF TEE.

STEP 2. DRILL HOLE INTO MAIN. CUT IS MADE WITH A MUELLER "CC" DRILLING MACHINE, HAND OPERATED, OR "C-1" DRILLING MACHINE, POWER OPERATED BY THE H-600 AIR MOTOR. WHEN CUT IS COMPLETED, SHELL CUTTER IS RETRACTED, GATE VALVE CLOSED AND DRILLING MACHINE REMOVED. LATERAL IS NOW IN SERVICE.



STEP 3. INSERT PLUG. COMPLETION PLUG IS ATTACHED TO INSERTING TOOL ON INSERTING BAR AND THE COMPLETION MACHINE IS BOLTED TO THE GATE VALVE. VALVE IS OPENED AND THE PLUG IS SCREWED INTO THE TEE. MACHINE AND VALVE ARE NOW REMOVED.



STEP 4. "BUTTON UP" TEE. PLUG IS TIGHTENED WITH SPECIAL PLUG WRENCH, GASKET IS POSITIONED AND THE COMPLETION CAP IS BOLTED SOLIDLY IN PLACE. INSTALLATION IS NOW COMPLETE AND READY FOR BACKFILLING.

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Teletype Service Expands

Communications on Buckeye Pipe Line

For More Efficient Operation

J. D. McCULLOUGH

PROBABLY no other industry is more vitally concerned with good "communications" than the petroleum industry.

Years ago, when the first pipe line was laid, right-of-way was also procured for constructing a communications pole line paralleling the route of the pipe line. Then, a single wire was strung for a Morse telegraph circuit used exclusively for communicating information between the main office and the pumping stations along the line. When this single-wire circuit failed, it was necessary for all pumping stations along the line to shut down until the circuit was repaired as no other types of communications were available. Small metal test boxes were attached to telegraph poles near road crossings, at four to six-mile intervals for the lineman's use in making tests to locate the cause and point of failure, which at its best was a slow and tedious method as well as costly in terms of reduced oil deliveries.

Today, with its tremendous scope, the petroluem industry requires a larger and more dependable communications system to keep pace with the intricate web of pipe lines throughout the country. These lines feed crude oils and refined petroleum products to the refineries and centers of distribution. The Buckeye Pipe Line Company is a common carrier of these products, transporting several hundred thousand barrels daily in seven states through its many hundreds of miles of pipe lines, which range from two to 22 in. in diameter. The company is confronted with the problem of serving this increased demand, plus the additional factors of:

1. Increased cost for cross-country pole line maintenance.
2. Congested pole tops through heavily populated areas, which leaves no space for additional circuits without a major rebuilding job.
3. Difficulty of maintaining sufficient clearance due to present-day demand for more and more electric power at higher voltages.

Buckeye has expanded its communications system by using American Telephone and Telegraph Company's private line teletypewriters, switching and selector signal equipment, as a means of providing better and more efficient communications. The first private line teletypewriters were installed on Buckeye's midwest products division between Robinson, Illinois, and Lima, Ohio. Later the system was extended to include Lawrenceville, Illinois, and Toledo, Ohio, with machines at all intermediate pumping stations and delivery terminals. At the present time, AT&T has recommended and installed their page printer sending and receiving machines with single service.

With this type service, communications may be carried on in either direction although not in both directions simultaneously. In most instances, all the machines on the circuit run continuously. When a message is sent, each machine automatically reproduces the message; therefore, it is not necessary for a receiving operator to be present at the machine. In addition to messages, various types of forms, reports and dispatching orders may be sent to unattended points on the system. Regular roll-type paper, either single or two-copy, is used. Machines with the sprocket-type paper provide the multiple copy.

Dial-operated selectors are used for tripping the relay to energize a loud audible bell situated in the pump and motor room at the pumping stations or outside the buildings at the delivery terminals. Purpose of this bell is to alert the operator to the fact that he is wanted at once at the teletypewriter, generally for the reason that something has gone wrong or a nonscheduled change is necessary along the pipe line system affecting the operation of his station.

It is general practice on the pipe line, especially on those systems designed for the movement of refined products, to have a central point of control—the dispatching department. One of the many important functions of the dispatching department is the scheduling of products through the pipe line in order to utilize fully the available line and pumping capacity. This, first of all, requires good communications to all points of operation along the system.

The dispatcher issues orders for the movement of each type of product to be pumped through the pipe line. The order is then sent by teletypewriter and received at all the pumping stations and delivery terminals, giving all an identically printed record. The dispatcher receives hourly reports from each pumping station regarding barrels pumped, pressures, temperatures, station load conditions, and, from the delivery terminals, amount of products received and recorded temperature.

This information is listed and identified by colors on the products dispatching board, providing a visual chart indication as to the location of the different batches of products moving in the pipe line and thus enabling the dispatcher to predetermine the time of arrival of the various batches at delivery terminals.

Since the original teletypewriter installations previously mentioned, Buckeye has installed teletypewriter equipment on a number of its other systems, the most recent being on the eastern products division from Linden, New Jersey, to Allentown, Pennsylvania, and Auburn, New York, with laterals to Syracuse and Caledonia in New York state.

To date, Buckeye has a total of some 3000 circuit miles of the private company teletypewriter service in use and the reliability of this service since initial installation has been 99.5 per cent.

This increase in teletype communication has resulted in increased efficiency, considerable economy and, of equal importance, it has enabled Buckeye to maintain operation as a dependable and efficient common carrier of crude oil and refined petroleum products.* * *

The Author

J. D. McCullough is superintendent of communications, The Buckeye Pipe Line Company. He joined the company in 1930 and worked in the communications and repair gang. In 1935 he was appointed telegraph repair foreman, and in 1946 promoted to assistant superintendent of telegraph. In that same year was again promoted to superintendent of telegraph. In 1948 he was made superintendent of communications.

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Measurement of Water Vapor in Natural Gas*

Recording instrument developed by Bureau of Mines and American Gas Association

W. M. DEATON

A MEANS of continuously measuring the water-vapor content of natural gas has long been recognized as one of the needs of the natural gas industry. This was brought out forcibly when the industry began to realize that water in natural gas pipe lines could cause trouble by the formation of gas hydrates. By keeping the gas transmission lines dry, gas hydrates could be avoided, but some means was needed of knowing just how dry the gas was.

During the course of a cooperative study of gas hydrates by the American Gas Association and the U. S. Bureau of Mines, a manually operated dew-point instrument was developed, and it has become more or less a standard instrument for measuring the dew point of gases. The need for an instrument that would give a continuous record of the dew point or water vapor content continued, however, and the cooperative project on gas hydrates was expanded to undertake the development of a recording instrument for the purpose. This phase of work was begun in January, 1949, and has resulted in the development of a recording instrument that has proved to be of practical value to the natural gas industry. The instrument is suitable for use with practically all natural gases and at all pressures encountered in present day operations. Its use is not limited to this service, however, as it has been used quite successfully at atmospheric pressure and in air streams and with other gases.

At the start of the investigation, a review was made of instruments and methods developed or proposed for the measurement of water vapor in or water dew points of gases. Instruments had been developed for recording the dew-point temperature of gases utilizing mirrored surfaces and photo-electric cells for detecting the appearance of dew as the apparatus was cooled. At least one such instrument[1] had been used in natural gas and was acceptable, so long as the water dew-point temperature of the gas was not lower than the temperature at which hydrocarbons would condense. Because natural gas pipe lines operated under relatively high pressures and frequently the natural gasoline dew point was above the water dew point, this instrument was not always suitable, and an instrument of a different type was needed.

The instrument developed by the Bureau of Mines during this co-operative study is suitable for recording the water-vapor content of natural gas where the dew point is not lower than about —20 F. The upper limit of water dew-point temperature detection is limited only to that of the ambient temperature. This is a rather wide range of temperature, and the whole range can be attained by only changing the water-sensitive element or the operating conditions of the recorder. For any particular sensing element or set of conditions, however, the range of the recorder is limited to a spread of about 20 F. So far as pressure is concerned, the instrument has been operated all the way from atmospheric pressure to 2500 psig, and there is no obvious limit to its use at even higher pressures.

The natural gas industry after learning of the development of the dew-point recorder, requested that it be made available if possible, even though the full study was not yet complete. In response to this request and a request by a manufacturer for permission to make the instrument, the Department of the Interior granted permission for its manufacture. The assembled instrument is shown in Fig. 1. As a result, a total of 35 instruments are, at present, in use in the natural gas industry, and an additional 14 are on order from the commercial concern manufacturing it, making a total of 49. As in indication of the interest of the natural gas industry, one pipe line company with widespread operations has in service or on order a total of 25 instruments. In addition to the above number of instruments in use, the Bureau of Mines, in its helium-production operations, is using four of the recorders on natural gas and an additional 15 recorders for special purposes on helium gas streams.

The following is a brief description of the development of the recorder. A more detailed report is being prepared for future publication.

Principle of Operation

At the beginning of the study, instruments and means available for measuring water vapor in gases were investigated. Although the dew-point method is basically satisfactory, the difficulties of using such a method in natural gas streams under pressure had been demonstrated by previous investigators, and it was obvious that condensation of hydrocarbons and accumulations of oil and dust on the dew-point mirror surface would interfere seriously and probably would be difficult to overcome. The electric hygrometer that previously had been developed by Dunmore[2] of the National Bureau of Standards, appeared to offer the greatest possibility of success, and the present instrument is based upon the use of this element. Consultation with Dunmore revealed that he had no plans or direct interest in developing the electric hygrometer for use

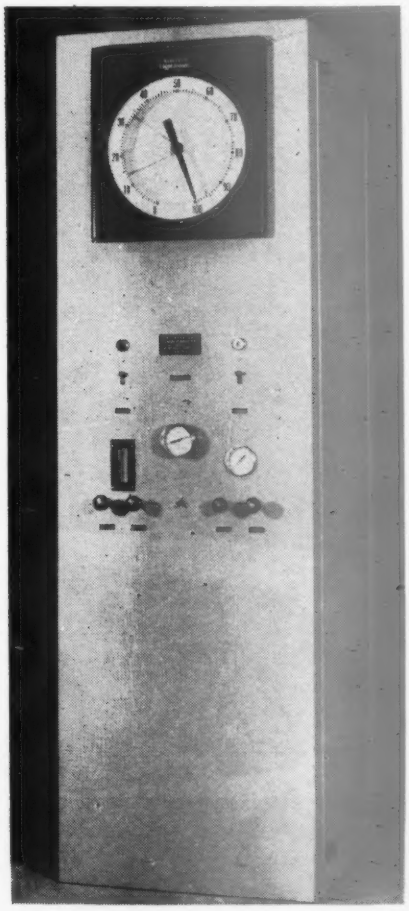

FIG. 1. Dew-point recorder for natural gases.

*Presented before American Gas Association Tranamission and Storage Conference, Chicago, Illinois, April 30-May 1, 1953.

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in natural gas streams under pressure, so this work was undertaken by the Bureau of Mines under the cooperative arrangement with the American Gas Association.

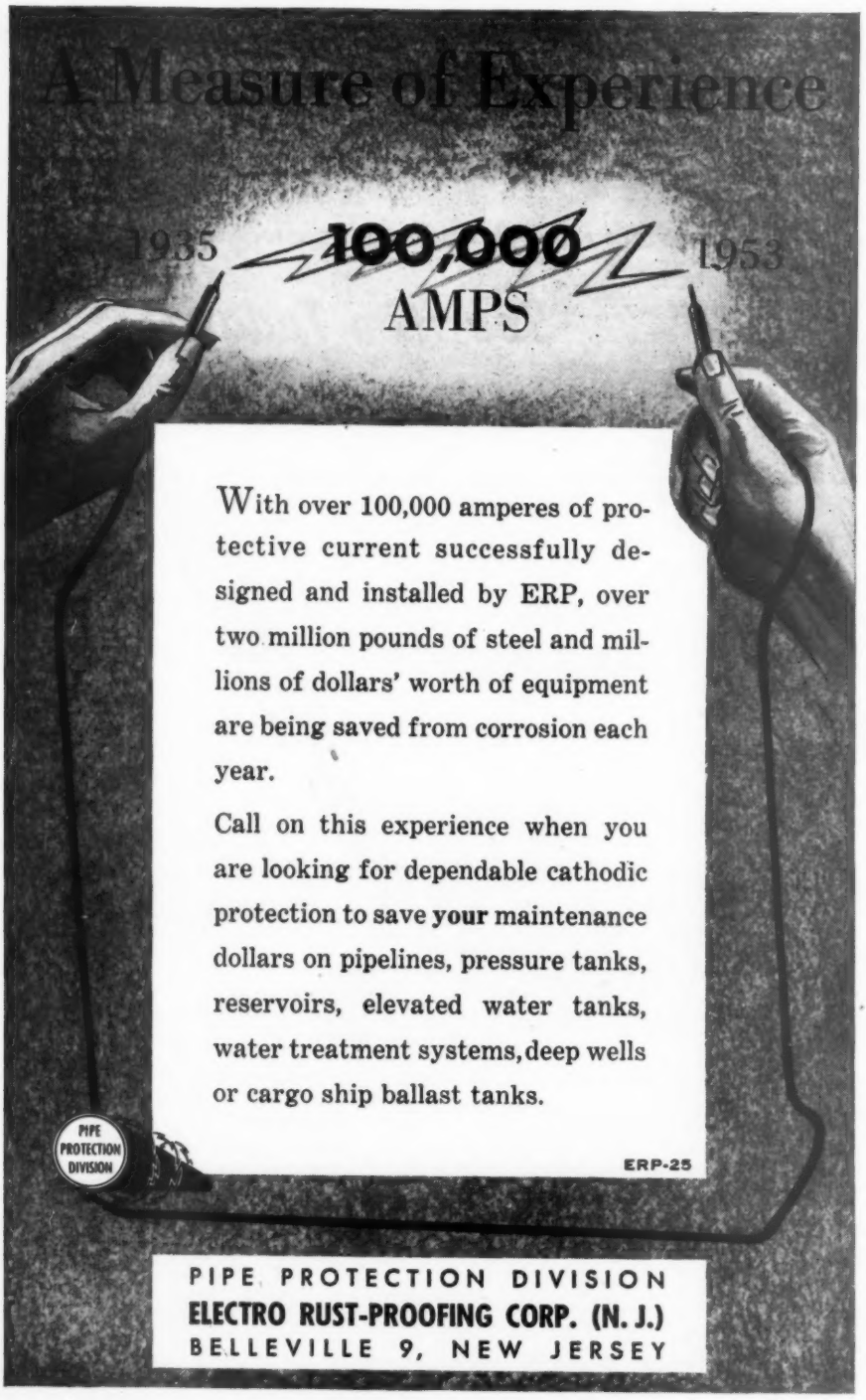
The following is a brief description of the construction and use of the Dunmore electric hygrometer element. The element is small, being approximately 1½ in. long by ¾ in. in diam. This is a size that is convenient to put into a pressure cell through which gas under test can be flowed. Two fine platinum or palladium wires (BS. No. 40) are wound in parallel or double-lead winding around a ⅜-in. plastic tube. The terminals of one end of the wires are imbedded into the plastic tube for anchoring. The other ends of the wires are attached to metal prongs on the base of the element enabling it to be plugged into a standard miniature radio tube-base socket. The ⅜-in. plastic tube is coated with a water-sensitive plastic film applied by dipping the tube with the windings on it into a water-polyvinyl alcohol solution containing a small percentage of lithium chloride. When dried, the polyvinyl alcohol serves as a binder for the lithium chloride. The water-sensitive film is only a few mils thick, and after being properly conditioned and aged, reaches a condition of constancy of calibration and responds very quickly to changes in the water-vapor content of the gas surrounding the element. In operation, a small alternating current (maximum, 100 microamperes) passes through the lithium chloride impregnated film on the element, and this current varies with the amount of water absorbed in the film, which, in turn, varies with the amount of water vapor in the surrounding atmosphere. The electrical measurement is essentially one of conductance, and this is translated by suitable electrical means into a recorder reading.

As the electric hygrometer is sensitive to the amount of water vapor in the surrounding atmosphere, it is not necessary to cool the gas being tested to a point where condensation of water occurs. The element is sensitive to temperature changes as well as water-vapor content changes, however; therefore, it is necessary to maintain the element and pressure cell at a selected constant temperature. It frequently is satisfactory to maintain the element at a temperature above ambient, and, in such cases, it is necessary only to provide a thermostating arrangement, whereby small electric heaters can intermittently supply the necessary heat to maintain the unit at the selected above-ambient temperature. When it is necessary to maintain the hygrometer at a temperature below ambient temperature, a means for cooling the system is provided, and the heaters and the thermostating arrangement are used to maintain the temperature at the selected below-ambient temperature.

Hygrometer elements coated with different concentrations of lithium chloride are used to cover different ranges of water-vapor content or dew points. Usually, any particular element will cover a range of water-vapor content corresponding to a dew-point change of about 20 F. Also, an element of a given dew-point range can, because it is temperature sensitive, be made to cover a different dew-point range by changing the temperature at which it is thermostatted. This fact makes it possible to use a single type of element to cover a fairly wide range of dew points, although it is necessary to vary the thermostatted temperature to cover the full range. Usually, 20 F is a satisfactory range for any particular installation; therefore, when once the conditions are

The Author

William M. Deaton is chief, research branch, helium division, U. S. Bureau of Mines. He is a graduate of the University of Missouri, receiving his bachelor's degree in 1921. He joined the Bureau of Mines that same year, and except for 1922, one year, has been with the Bureau's helium work. He received his present appointment in 1950, and prior to that dealt with helium and natural gas research.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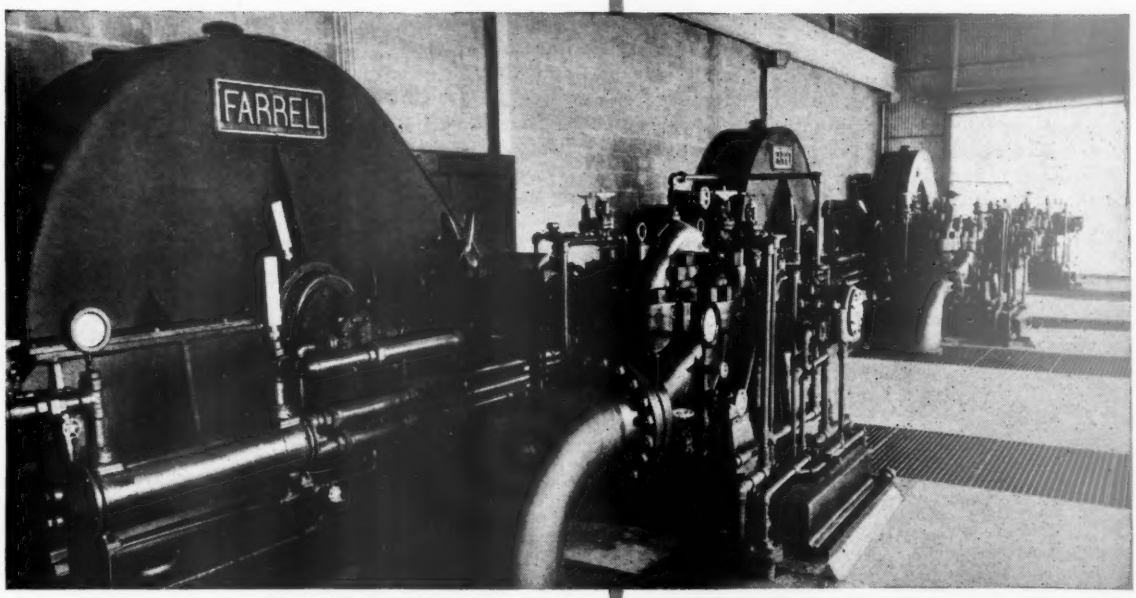

Venezuela's new 30", 165-mile, crude-oil line has a single pumping station, located at Palmarejo de Mara. There, three Farrel speed increasers are each transmitting 1,850 HP from a Cooper-Bessemer Gas-Diesel engine to a Byron Jackson pump, stepping-up the speed from 314 to 2500 RPM. Provision has been made for conversion of the Cooper-Bessemer engines to turbo-charged operation, with an increased rating of 2500 HP each. The Farrel units are designed to transmit 2550 HP.

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known, it is not necessary to change the thermostatted temperature.

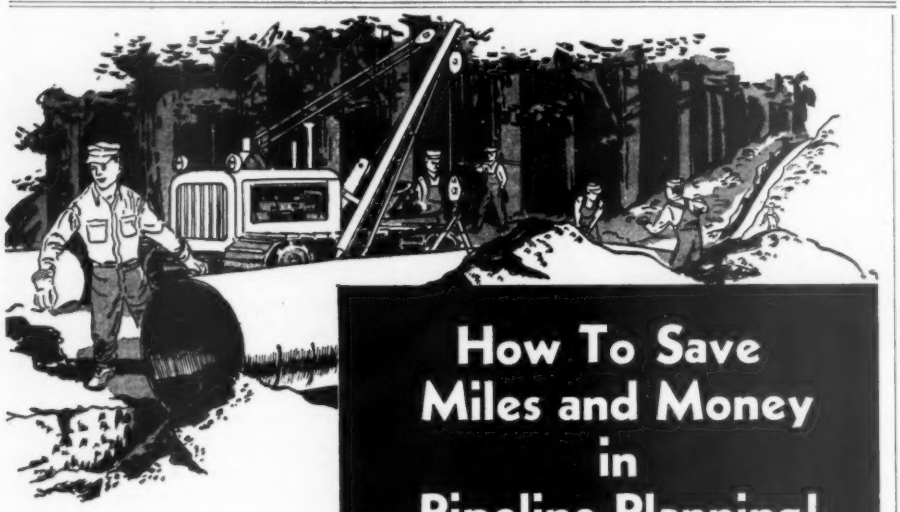
The electrical system used to record the water-vapor content or dew point of the gas under test employs alternating current throughout. It is necessary to use alternating current through the hygrometer element to avoid polarization, and by using alternating current for the potentiometer circuit of the balancing electrical bridge also, it is possible to eliminate almost entirely effects of fluctuations in line voltage that exist in the electrical power source. This matter required considerable investigation before it was finally solved.

The electrical hygrometer unit is not particularly sensitive to anything in the gas stream except water vapor. It is sensitive to vapors that would attack the plastic base upon which the electrode wires are wound. With the present elements, this would probably be aromatic hydrocarbons, and since the binder used to hold the lithium chloride in place is polyvinyl alcohol, the vapors of methyl, ethyl and other alcohols would likely affect the element adversely. Hydrocarbon vapors other than aromatics, however, have not been found to affect the element adversely. As a matter of fact, it is possible to wash the element in gasoline that has been thoroughly dried by use of silica gel, alumina, or other effective drying agents. An oil film on the element slows down its response to changes in water vapor, but does not keep it from functioning. Provision is made in the construction of the recorder to trap out any liquids that might be carried over in the gas stream, and a micrometallic filter is used to stop any dust carried by the sample gas.

It has been found that small percentages of carbon dioxide or hydrogen sulfide do not affect the hygrometer element, although no tests have been made where these gases are present to a considerable extent. The presence of glycol vapors or amine vapors, however, have been found to affect the element adversely. Means have been provided to filter out any glycol vapors that might be present in the gas by using a very small adsorbent filter consisting of activated alumina or silica gel. Such means have not been found adequate to eliminate amine vapors, but successful operation has been obtained by placing a small scrubber charged with oleic acid in the sample stream ahead of the hygrometer cell. These scrubbing devices delay slightly, but not too greatly, the response of the recorder to changes in water-vapor content.

The hygrometer element is only slightly affected by pressure. The effect is large enough, however, to recommend that the recorder be calibrated under the pressure conditions of use. The most satisfactory means of calibrating the recorder is to use the Bureau of Mines' type dew-point tester. This is readily accomplished by inserting a small adsorber in the sample stream to remove water, then adding variable controlled amounts of water vapor to cover the range of the recorder. This may be done by passing a small portion of the dried gas through a side-stream water saturater and rejoining it with the main stream ahead of the hygrometer cell. Then by connecting the dew-point instrument to the outlet of the hygrometer cell and maintaining the same pressure in both the hygrometer cell and the dew-point instrument and controlling the flow at the outlet of the dew-point instrument, the dew point of gas at the pressure under test for each condition of water-vapor content can be determined directly by means of the dew-point instrument. In case of interference due to condensation of hydrocarbons, it is recommended that the sample gas stream be passed through coconut charcoal to remove the gasoline just prior to the removal of water vapor during the calibration tests. This permits satisfactory dew-point determinations to be made without interference from hydrocarbon condensation even at the lower dew points.

As a hygrometer element responds primarily to the partial pressure of water vapor in the atmosphere surrounding it, and this is related directly to the temperature of water saturation (the dew-point temperature), the instrument can be calibrated most readily directly in water dew point. By referring to water-vapor content curves for the natural gas under test, the quantity of water vapor in the gas per unit volume of gas can be determined. If it is desirable to



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have the recorder register water-vapor content directly—for instance, in pounds of water per MMSCF—then a pressure regulator set slightly lower than the minimum pressure of the gas stream, can be placed in the sample line just ahead of the instrument to maintain a constant pressure in the hygrometer cell. In this case, the dew-point calibration can be converted directly into water-vapor content by substituting the corresponding water-vapor contents read from a constant pressure line representing the chosen pressure.

During the investigation, it became quite evident that the sampling lines to the recorder needed to be given appropriate attention. The line should be small enough to be flushed out in a suitably short time to reflect the conditions to gas passing the sampling point in the natural gas pipe line. If the sample line is not short, an extra purge-flow should be taken from the line near the instrument to cut down on the time lag. For the same reason, the sampling line should be small in diameter. Usually, a ¼-in. tubing line is very satisfactory. The line should be clean, as, otherwise, water will be sorbed and desorbed by the scale and dirt in the line and give slow response to changes in the water-vapor content of the gas passing the sampling point in the natural gas pipe line. Further, when the sampling line contains absorbing material, changes in temperature will give false readings due to sorption or desorption of water vapor with changes in temperature of the sampling line. It is recommended that new, clean tubing, either copper or aluminum, be used for the sampling line. The sampling line temperature should never go below the dew point of the gas in the gas transmission line, for if it does, water condensation will occur in the sampling line, and the recorder reading will be correspondingly affected. This would dictate that the line either be buried underground, where its temperature will not be lower than the dew-point temperature of the gas flowing in the gas pipe line, or that provisions be made to heat the sample line between the sampling point and the recorder.

After installation, the recorder requires very little attention. It is rugged and does not require much care. At an installation where one of the recorders has been operating for a period of 3 years or more, the instrument is sitting in a small unheated "doghouse," typical of orifice meter houses, where the recorder is subjected to all rigorous changes in weather conditions, except that it is protected from rain. Even under severe weather conditions, either of temperatures below 0 F in the wintertime or high temperatures exceeding 100 F in the summertime, the recorder has never failed to give a satisfactory record.

Although, usually, the hygrometer cell can be kept at a temperature above ambient for ranges of dew-point temperature between 10 F to 30 F and higher, if a lower range of dew-point

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temperature is desired, some cooling of the hygrometer cell block is necessary. Frequently, this can be accomplished merely by expanding some the high pressure gas through the cooling coil attached to the outside of the block. Where unusually low dew-point temperatures are to be covered by the recorder, the cooling principle of the "vortex tube"[3,4] can be used. In all Bureau of Mines' installations of the instrument, a "vortex tube" cooling arrangement is used. With 400 or 500-psi gas, it is quite easy to effect a cooling of 30-40 F below ambient temperature. This is one of the first applications for utilizing the refrigeration from a "vortex tube." Although its thermodynamic efficiency properly can be questioned, its simplicity of construction and freedom from operating troubles recommend it for use in this instance.

Although it would be very difficult to make the recorder entirely explosion-proof, the Bureau has incorporated in its recorders explosion-proof equipment at the points where any dangerous arcing of electric current is likely. The recording instrument itself is not made explosion-proof, but the rest of the equipment is. Needless to say, the addition of explosion-proof equipment would increase the cost of the recorder very materially.

One of the uses to which the recorder may be put is to automatically control the water dew-point of gas being sent out from a plant. At one natural gas plant, this is done by incorporating control equipment in the dew-point recorder that will permit some of the gas to bypass the dehydrating plant, thus controlling the dew point of the outgoing gas. The bypass valve closes more and more as the dew point of the gas coming out of the dryer increases until, finally, the bypass valve is completely closed, and the drying tower is taken off the line.

Summary

As a result of this cooperative study between the Bureau of Mines and the American Gas Association, an instrument to record the water-vapor content or dew point of natural gases has been developed. The recorder has been given extensive practical tests and has been found to perform quite satisfactorily. It requires very little maintenance, can be checked easily, and is sufficiently rugged to permit its use where it can receive very little attention. The natural gas industry already has accepted it for routine use at certain locations.

☆ ☆ ☆

Radioactive materials are now being used by oil companies as "labels" for different kinds of oil being moved through pipe lines. Geiger counters trace the radioactive material and when it reaches the terminal it enables the operators to make a better withdrawal of their consignments.

In keeping with original plans and arrangements with the American Gas Association, a patent application was made by the inventor, and U. S. Patent No. 2,629,253 has been issued. In keeping with Government practice, the patent is assigned to the United States of America, as represented by the Secretary of the Interior, in whose hands the licensing of manufacture of the instrument lies. A manufacturer has applied for license to make the instrument for sale, and through temporary previous arrangements, has made approximately 50 of the instruments.

Work on this project is finished except for preparing a detailed writeup of the development. This is under way at the present time. Appreciation is extended to those in the American Gas Association and in the natural gas industry who have assisted in the work, particularly those who offered their facilities to make practical installation tests of the recorder.

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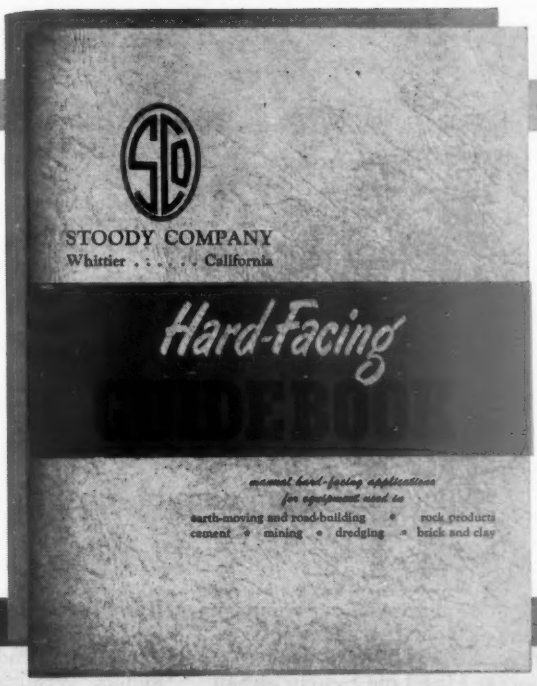

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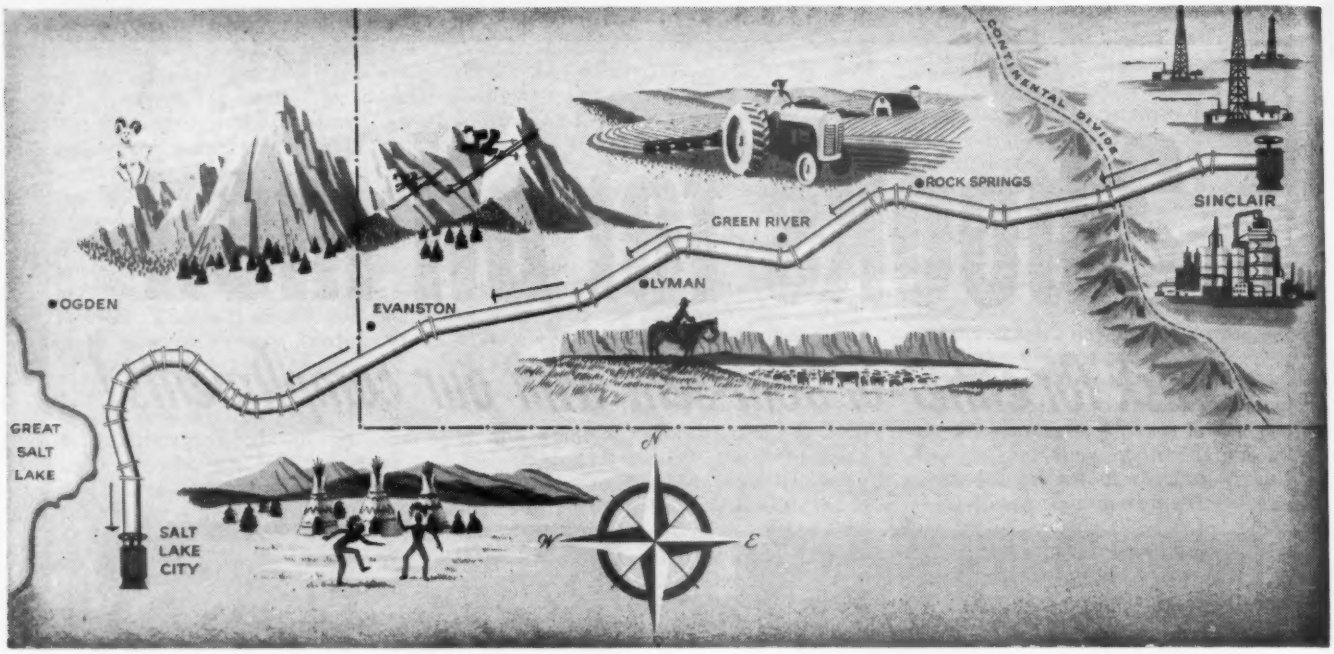

SYSTEM MAP of the Pioneer Pipe Line Company through Wyoming and Utah (terminal).

Products Pipe Line in Operation

Pioneer Pipe Line's 290-mile, 8-in. products system will serve the intermountain empire, give Continental and Sinclair regional outlets

PETROLEUM products are now moving through one of the nation's newest transportation facilities following dedication of the Pioneer Pipe Line System at Salt Lake City during August.

The 290-mile, 8-in. line is jointly owned, 65 per cent by Continental Oil Company and 35 per cent by Sinclair Pipe Line Company. It originates at Sinclair's refinery at Sinclair, Wyoming, and proceeds in a westerly direction in the general neighborhood of the route of the Lincoln highway and the Union Pacific railroad by way of Rock Springs, Green River and Evanston to North Salt Lake City.

Appropriately named, the Pioneer Pipe Line serves the sturdy intermountain empire founded by the hardy Mormon pioneers who forced their way across the arid Wyoming plateau country just five years prior to this time in the last century. The name "Pioneer" was adopted in honor of those early Americans who conquered these large stretches with the transportation facilities available over a century ago and reclaimed the desert section of Great Salt Lake Basin.

Near Salt Lake City the new pipe line connects with the Salt Lake Pipe Line Company's system, through which it delivers products to the Snake and Boise River valley areas in Idaho and Eastern Oregon and in the Columbia River basin of the Pacific northwest at Pasco, Washington. Terminal outlets in the Snake and Boise River valleys are located at Burley and Boise, Idaho.

The construction of the Pioneer Pipe Line assures the substantial participation of two major marketers, Continental and Sinclair, in the intermountain region. At the same time it supports the economy and growth potentialities of the section with the crude reserves of the whole upper Rocky Mountain region.

Line Crosses Divide

The pipe line system originating at Sinclair, Wyoming, climbs from 6600 ft to the Continental Divide near Cresson, Wyoming, at an altitude of 7120 ft, and reaches its maximum elevation at the Bear River Divide east of Evanston at 7660 ft.

At Wasatch, Utah, the line crosses the Wasatch Divide at 7400 ft and then begins its rapid descent into Lost Creek Canyon, which it follows to its junction with the Echo Canyon at Devil's Slide. From here it trails the Weber River to its point of emergence into the Salt Lake Basin and continues in a southwesterly direction to the Salt Lake terminal site in North Salt Lake on the Union Pacific railroad. The line profile descends approximately 3400 ft in the last 70 miles.

At present the line has one pumping station, which is at Sinclair, Wyoming, providing an average capacity of approximately 12,000 bbl per day.

Line Construction

Four companies furnished pipe that went into the system. Seamless pipe was 24.70-lb grade X-46 and was located in the line on the downstream side of the initial station and the future intermediate station site near Green River. Electric weld 24.70-lb grade X-42 pipe was located next to the seamless on the Sinclair end of the line and the electric weld 28.55-lb grade X-42 pipe was laid on the western end of the line and a section immediately east of the Green River station site.

Radiographic examination of a percentage of the welds along the line was used on the entire construction job.

Coating consisted of 3/32-in. minimum thickness of coal tar enamel and a wrapper of fiberglass pulled into the tar with a final wrapper of kraft paper over all.

The largest river encountered was the Green River, which was crossed at the town of Green River, Wyoming. Several

Westinghouse Microwave Letter

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Multiplex Assembly Combines Frequency Division, Unit Design, Crystal Control

The many useful functions of a microwave communications and control system rely heavily on the merits of its multiplexing equipment. So fundamental is this equipment to overall microwave dependability that Westinghouse placed first emphasis on superior multiplex design in creating its 2000 MC system.

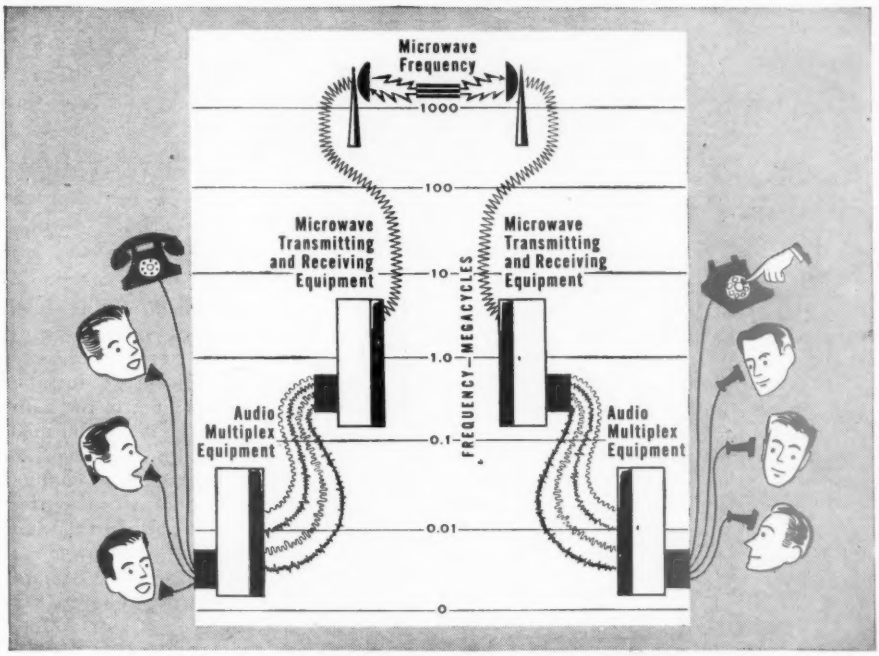
Strict Channel Independence

Years of Westinghouse experience in microwave communications — and in control systems generally — are the basis for this latest design. User requirements, freshly evaluated, pointed to the single most important "basic" of a microwave system: multiplex channels must be as independent of each other as possible. Westinghouse 2000 MC Microwave achieves this independence to a remarkable degree — and thereby attains an exceptionally high level of communications reliability for both voice and control.

For strict channel independence, Westinghouse 2000 MC multiplex equipment (called Type FJ) includes three interfunctional elements: self-contained voice and telegraph panels . . . crystal control of each and every frequency . . . multiplexing by the completely efficient method of frequency division. The result: if one channel develops a fault, all other channels continue to operate without interruption.

Individual Power Supplies

Type FJ equipment includes only four panels: Voice Band Panel, Telegraph Transmitter, Telegraph Receiver and Telegraph Power Supply Frame. These basic units supply up to 30 voice or telegraphic channels or any required combination—a capacity fully able to meet most present and future needs. Even greater telegraphic capacity is available by submultiplexing each channel with up to 15 additional telegraphic functions.



Frequency-division multiplexing in Westinghouse 2000 MC Microwave: individual audio signals modulate Type FJ Multiplex units (300-600 KC range)... composite output frequency modulates Type FR Radio (2000 MC band).

The Type FJ panels are so completely flexible that they operate on any channel frequency, requiring only a change of crystal and retuning. Each Voice Band Panel is entirely self-sufficient, even to having its own individual power supply. There is no reliance on a central supply that would, upon failure, incapacitate the whole or a critical part of the microwave system.

Simpler Circuits, Stable Frequencies

Westinghouse microwave takes full advantage of the inherent reliability of frequency-division multiplexing by incorporating simpler circuits. Maintenance savings are increased . . . personnel training is made easier. Reliability is further assured through crystal control of frequencies. High stability results, providing frequency coordination over wide ranges of input voltage, temperature, and other variable conditions.

Westinghouse 2000 MC Microwave radio equipment is as carefully designed and engineered as this flexible, reliable multiplex equipment. Westinghouse microwave equipment benefits from the years of valuable manufacturing and application experience Westinghouse has had with all types of end-use devices. For full information call your Westinghouse representative or write: Westinghouse Electric Corporation, Electronics Division, Microwave Section, 2519 Wilkens Avenue, Baltimore 3, Maryland.

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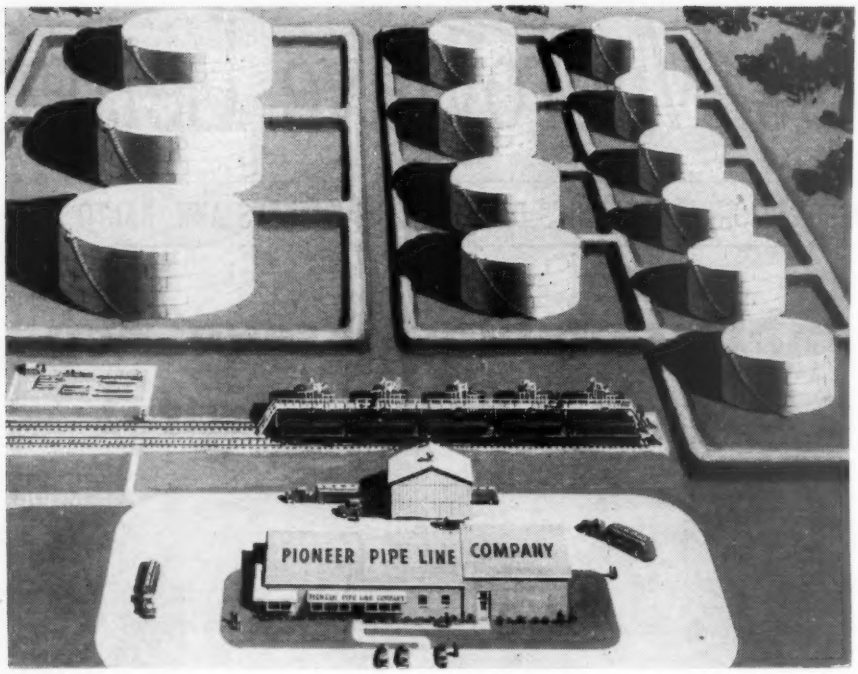
YOU CAN BE SURE... IF IT'S Westinghouse

J-02277



SALT LAKE CITY terminal provides 500,000 bbl of storage.

crossings of the Weber River were necessary as it descended through its canyon at the westerly end of the system.

In preparation for corrosion mitigation on the line, test points were installed at approximately two-mile intervals as the line was constructed. Rectifiers will be used for corrosion protection. Numbered aerial markers also were placed at two-mile intervals where practicable.

Sinclair Station Equipment

The station at Sinclair is electrically driven, using full voltage starting outdoor switchgear and explosion-proof motors. Four pumping units are installed at the pumping station at Sinclair, Wyoming—three are 400 hp units, and one 200 hp unit.

Six-stage, 4 x 6 pumps are used with the 400 hp units and a two-stage pump for the 200 hp unit, all with mechanical seals. The rotors of the 400 hp units are sized differently so as to be able to use them in various combinations, giving flexibility of pressure as products with different specific gravities are pumped. The 200 hp unit represents the approximate difference in the pressure required between the lighter gasolines and the heavier distillates.

Two large units and a small unit are required to pump gasoline and two of the large units will be required for pumping distillate. This gives one full unit standby under any condition for this initiating station.

Sinclair's refinery at Sinclair, Wyoming, furnishes the products for transportation through the line. Individual suction lines are laid to the supply tanks and two booster stations installed near the station manifold for supplying the net positive suction head required for the station pumps.

ASA standard 900-lb valves and flanges with schedule 90 fittings were used in the line block valves, scraper traps and station discharge headers.

Motor operated valves are installed on the individual tank lines at the manifold so that tank changes can be made at the switchboard and at the same time main pump unit combinations changed to accommodate the gravity of the product that will be coming in. In this manner excessive throttling and power consumption, as well as excessive demand, will be prevented, which will have a very large effect on the power costs. Motor operators are also installed on the suction and discharge valves to the main pumps, the operation of which is interlocked in the individual units starting sequences.

The pump house building at Sinclair station is of brick construction, with monolithic concrete providing modern lines.

Salt Lake Terminal

Salt Lake terminal in the northern part of North Salt Lake near Woods Cross is built on a 68-acre site adjacent to the Union Pacific railroad from which a spur serves a 10 spot tank car loading rack. Storage provided at the terminal is 500,000 bbl, distributed as follows: Three 80,000-bbl tanks; two 40,000-bbl tanks; two 30,000-bbl tanks; and six 20,000-bbl tanks.

In addition to the tank car loading racks, a tank truck loading rack will load products for the local market available to tank trucks from Salt Lake City. The rack is designed to service the largest tank truck in use without having to move it after loading has started. The loading spouts from any meter are connected to flexible hoses and an overhead trolley arrangement so that any meter can load any one of the truck compartments. This has the additional advantage of making it possible to load more than one compartment simultaneously.

Since the largest volume of products transported is house brand or regular gasoline, two spouts are provided on each side for this product, making it possible for a tank truck to load two compartments of house brand gasoline and one with premium gasoline at the same time. Trucks that are designed to haul burning oils with the gasoline loads can add the loading of those products simultaneously with that of the gasolines. Loading rates are 600 gpm through meters.

The Salt Lake Pipe Line System, which transports products from the Pioneer to terminals at Burley, Boise and Pasco, consist of a double 8-in. line from Salt Lake to Boise and a single 8-and-6-in. line from Boise to Pasco. At present one line is operated as a "local system" from Salt Lake to Boise, delivering all of the products used along this route. The other line is used as an "express line" to Boise, making no deliveries short of that point and transporting all products delivered beyond Boise, which includes the terminus of the line at Pasco.

Transfer Lines Laid

As products from the Pioneer system are transported in both lines, two 10-in. transfer lines of more than two miles in length were laid from the Pioneer terminal to the pump station on the Salt Lake Refinery Company's site. Deliveries are fed into Salt Lake Pipe Line suction at pressures between 50 and 125 psi at rates of flow varying from 17,000 to 33,000 bbl per day. Effort is made to schedule the products in such a way that each transfer line will be left full of the next type of product that will be batched out. When circumstances might make this impossible, a 6-in. return line provides facilities for purging either of the 10-in. transfer lines and starting delivery into the Salt Lake Pipe Line suction of whatever product conditions might demand.

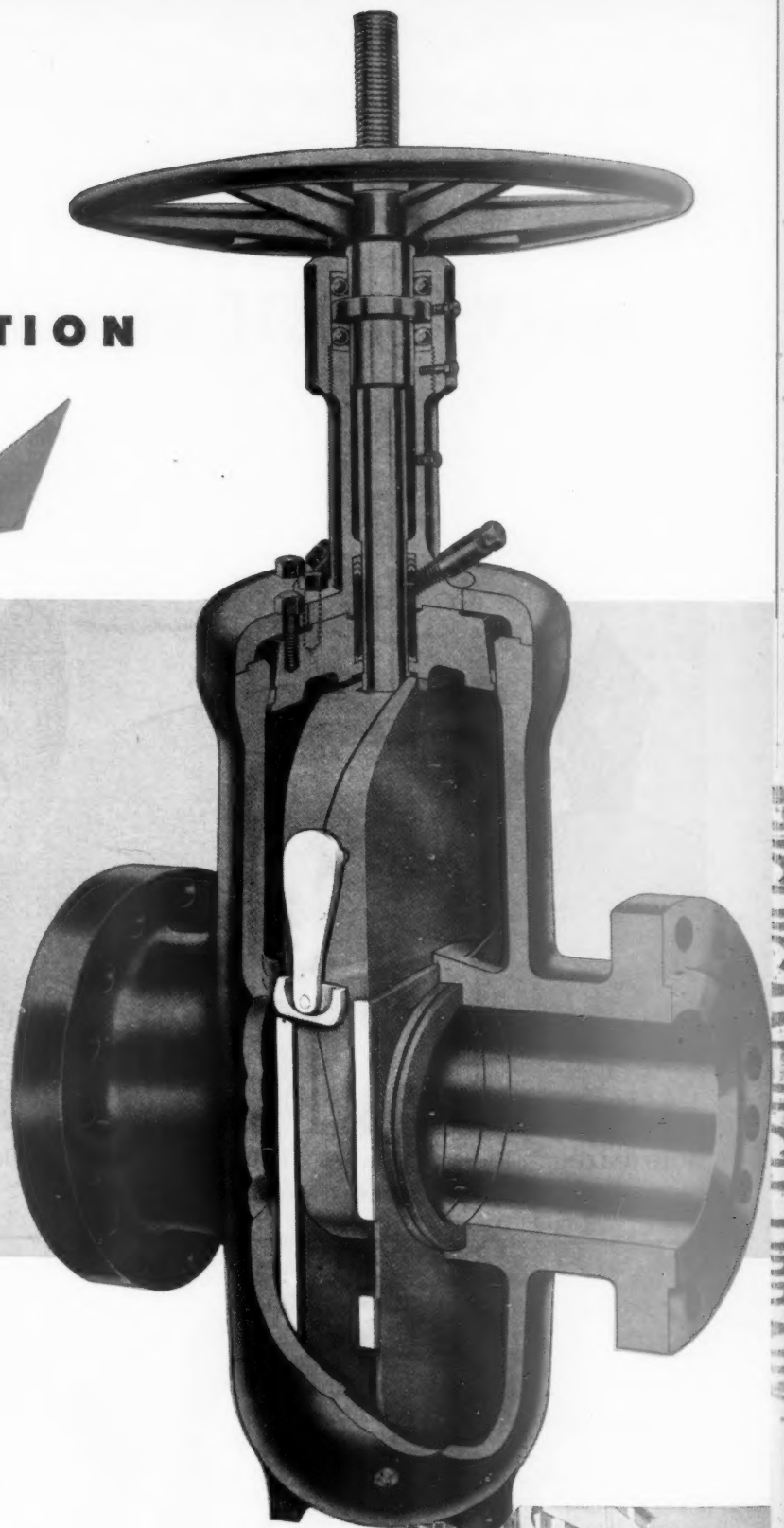
The operating headquarters office for the Pioneer system is located at the Salt Lake City terminal. It also serves as the terminal office and includes a warehouse, shop, and work vehicle storage space. Communication between the headquarters and terminal offices at Salt Lake City and the station at Sinclair is maintained through leased teletype facilities.

Because of the 3400-ft fall in elevation in the last 70 miles of the line coming into the Salt Lake terminal, back pressure controls are necessary at the present rates of flow to prevent the separation of the liquid column at the top of the mountain.

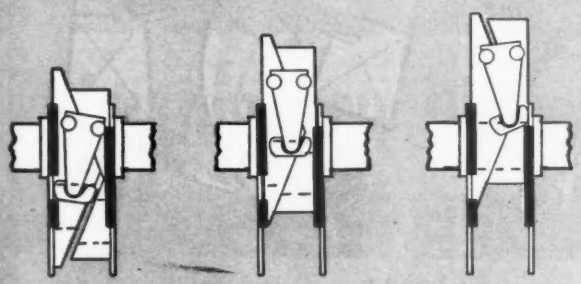
When operating at the full capacity of one station, the back pressure at Salt Lake City of approximately 600 psi is required to prevent the separation of liquid column at the top of the Wasatch Divide. Under the flow rate that will exist under two station operations, however, practically no back pressure will be required at Salt Lake Terminal.

* * *

EXCLUSIVE LEVERLOCK ASSURES POSITIVE OPERATION in W-K-M VALVES



Leverlock action guarantees that W-K-M Valves always open and close efficiently. It controls neutral position of the gate and segment while opening or closing the valve . . . permits expansion of gate assembly *only* at proper time for seating in opened or closed position . . . assures positive controlled gate and segment pressure against *both* the upstream and downstream seats.



Gate and segment in closed position. | Neutral position. | Completely open.

The basic W-K-M Through Conduit Design and expanding gate have proved unequalled in the most severe tests. These, combined with Leverlock operation, no surge operation, simple maintenance, quick overhaul in the field, make W-K-M Pipeline Valves top standard for the industry. When you want dependable valve performance, specify W-K-M Valves all the way.

W-K-M COMPANY

P. O. Box 2117 Houston 1, Texas
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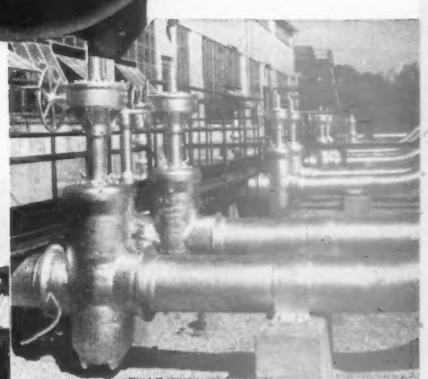
W-K-M Valves

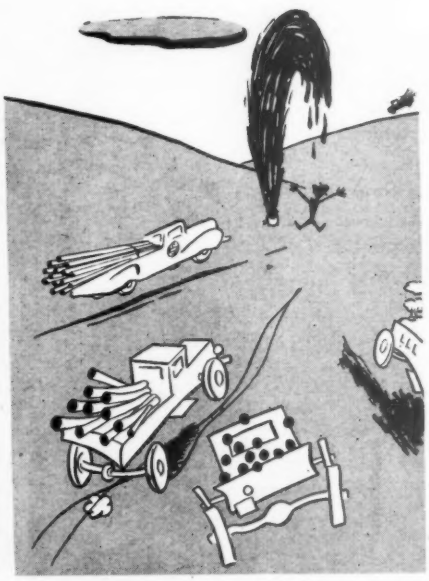


A Short, Short Course in Economics

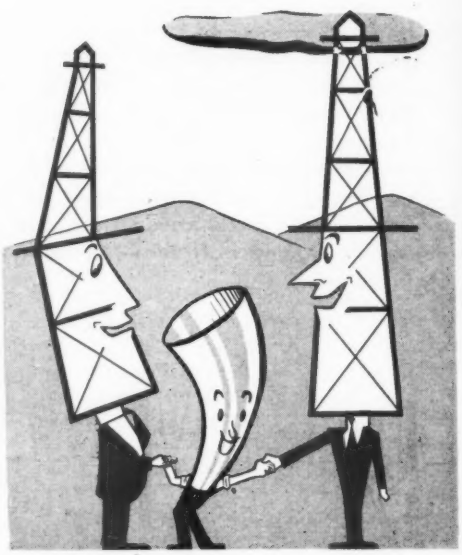
WHY MODERNIZE?

Pipelining has the same problems to face that most other industries do in these times. To get there "the fustest wih the mostest" is the desire of every supplier of services. It's a competitive business, however, and the supplier with the most efficient and economical service usually has the advantage. Efficiency and economy depend on many things, not the least of these being modern equipment and operation. Pipeliners often are asked "why modernize?" The cartoon series presented here, from Service Pipe Line Company's *Connecting Rod*, presents one of the best illustrated answers we have seen in some time. Bringing old equipment up-to-date benefits everyone—shipper, transporter, employees, investors. * * *

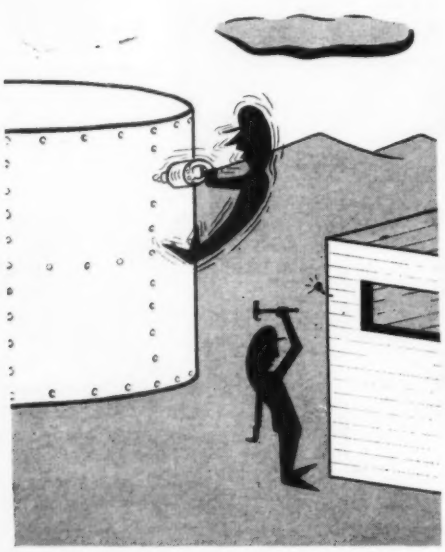
MODERNIZING equipment gives better working setups, economic operation.



ECONOMIC operation means lower rates for shippers of petroleum.



LOWER rates attract more business that competition otherwise would get.

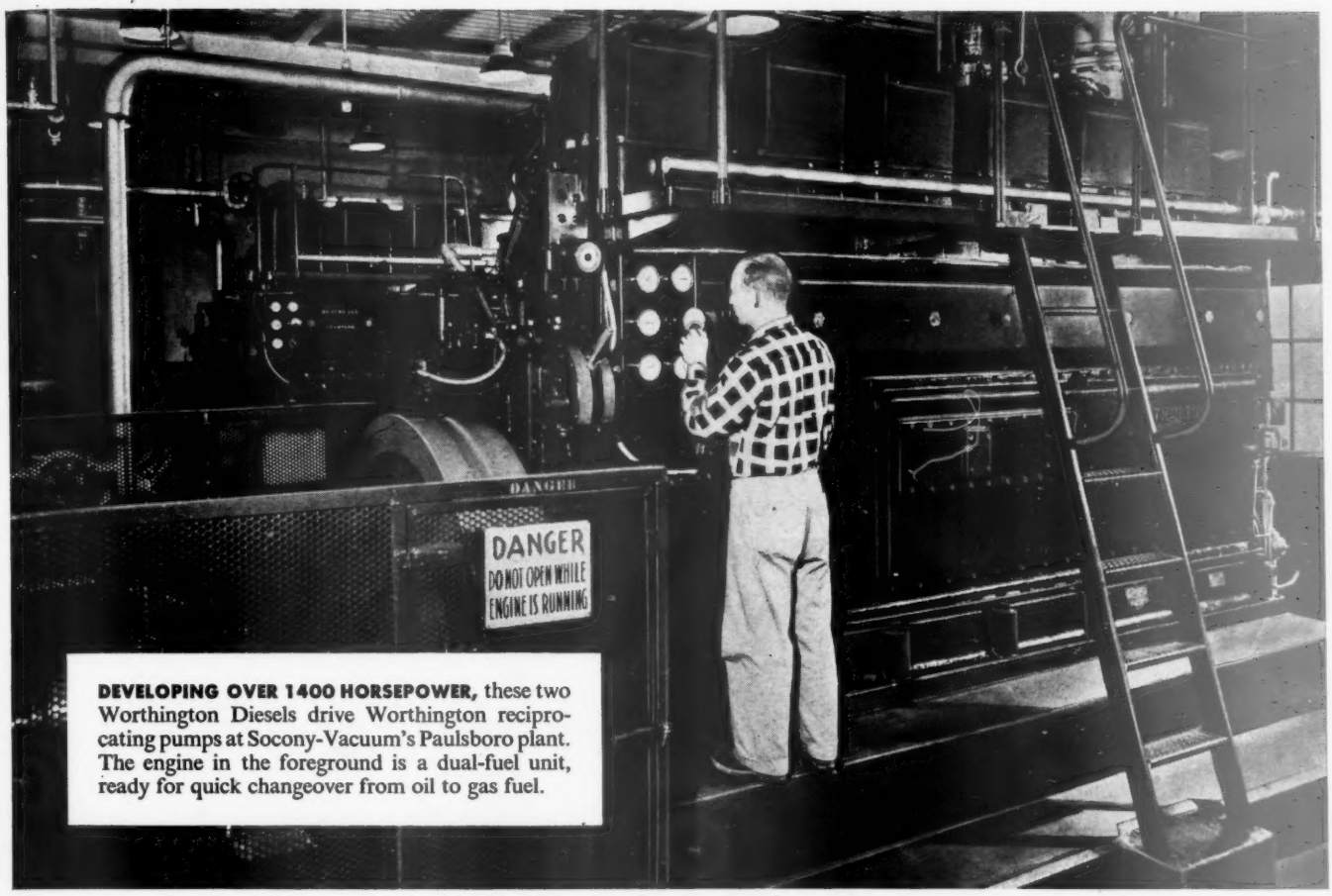


INCREASE in business means expansion of facilities to transport the oil.

EXPANSION of systems means more and better jobs and opportunities.

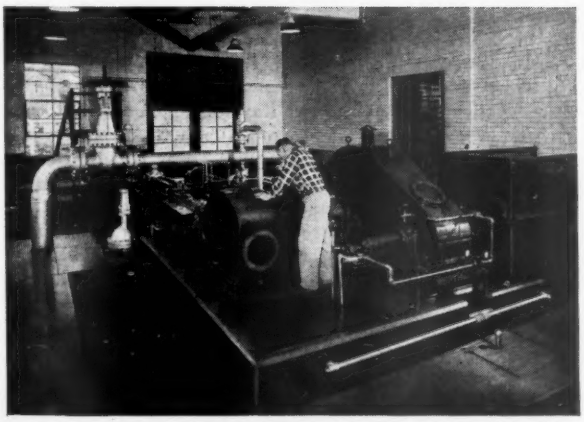
EXPANSION and improvements mean continued security for employees, investors.

XUM



DEVELOPING OVER 1400 HORSEPOWER, these two Worthington Diesels drive Worthington reciprocating pumps at Socony-Vacuum's Paulsboro plant. The engine in the foreground is a dual-fuel unit, ready for quick changeover from oil to gas fuel.

Worthington Diesels power pumps along Socony-Vacuum line



DRIVING WORTHINGTON RECIPROCATING PUMPS like this one at the Paulsboro station is the job that Worthington engines along Socony's pipeline do with complete dependability. At the McCrea, Pa., booster station—midway along the line—continued pumping depends entirely on the driving power of a single Worthington Diesel, since no standby unit is used.

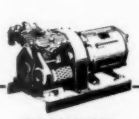
From their refinery at Paulsboro, New Jersey, through a booster station at McCrea, Pa., the Socony-Vacuum Oil Company pumps refined oil products across Pennsylvania to Pittsburgh.

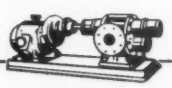
Three Worthington Diesels—two at Paulsboro and one at McCrea—furnish all the power for driving the pumps on this 300-mile pipeline.

Socony-Vacuum's long, satisfactory experience with these dependable and efficient Worthington engines is duplicated by pipeline companies everywhere. Users know that when they buy Worthington dual-fuel Diesels they're getting the most for their dollar. The ability of the Worthington dual-fuel units to operate on crude oil from the line, Diesel oil, gas, or any combination of gas and oil, assures economical operation under all conditions.

Get all the facts on Worthington Diesels, dual-fuel or gas engines. Write to Worthington Corporation, Engine Division, Section E.3.4, Buffalo, N. Y. E.3.4

Worthington-Built Auxiliaries


ENGINE STARTING COMPRESSORS


OIL TRANSFER PUMPS,

COOLING WATER CIRCULATING PUMPS

EVAPORATIVE-TYPE ENGINE WATER COOLERS

Economical Continuous Power—Diesels, Oil and Dual Fuel, and Spark-Ignition Gas Engines, from 150 to 2100 bhp.

WORTHINGTON
Engines

Pipeline Pictorial

Men, Machines, and Methods

BULLDOZER (upper left) works on diverting the channel of the San Juan River preparatory to laying an El Paso Natural Gas line in the San Juan Basin area.

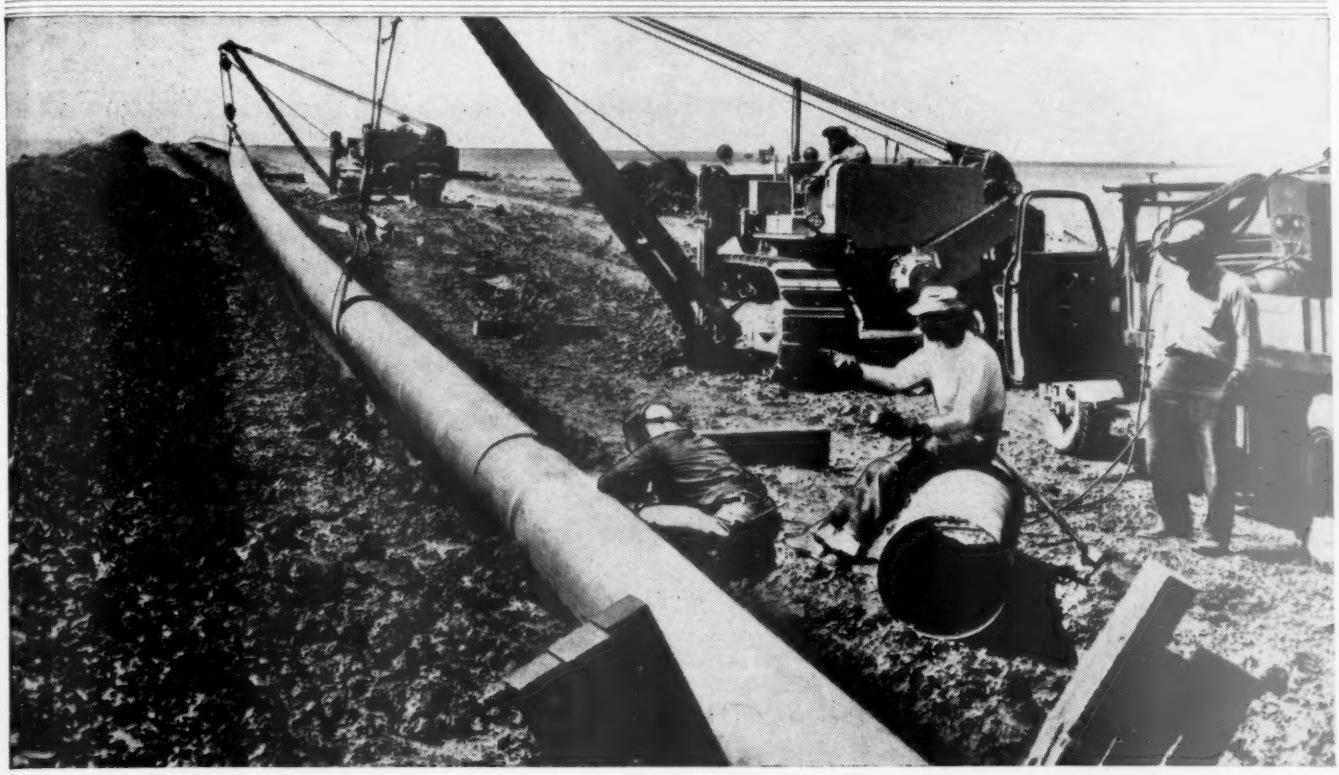
SIDEBOOM TRACTOR (upper right) makes a big lift on El Paso Natural construction job near Blanco, Texas.

REMINDER (right center) to personnel to stay "in-bounds" is posted by Jimmy Trentham, safety engineer for H. C. Price Company, on a Texas Gas project right-of-way in Kentucky. Reduced right-of-way damage means more goodwill of the landowners and savings of many dollars.

PERSONNEL (left center) of Magnolia Pipe Line Company get together in South Texas to talk things over. Left to right are J. L. Barnes, chief engineer, Waelder; Jerry F. Gleason, southwest Texas district chief electrician; Carl Duderstadt, electrical engineer, and Rey W. Stewart, Luling district superintendent.

(Below) **MOST** popular course sponsored recently by the Institute of Gas Technology, Chicago, was the "Transmission and Distribution" short course held. The attending are shown below, front row: R. F. Bukacek, IGT instructor; Albert W. Buckley, Roanoke Gas; W. M. Stanley, C. J. Conrad, and R. K. Hansen, Manufacturers Light and Heat; IGT Director E. S. Pettyjohn; William N. Darling and Henry F. Giblin, Peoples Gas Light and Coke; Roy F. Roberts and James H. Rhodes, Jr., Alabama Gas; Bert E. Eakin, IGT instructor. Second row: Mal C. McCallum, Seattle Gas; Bernie Wilenzick, Interstate Natural Gas; Harry A. Moore and Harry J. Schneider, Rockwell Manufacturing; Kenneth Wharff, Michigan-Wisconsin Pipe Line; Charles S. McGee, Kansas-Colorado Utilities; Donald C. Hulbert, Rochester Gas and Electric; Tom B. Henshaw, Portland Gas and Coke. Third row: Paul A. Hoglund, Seattle Gas Company; Parry Keller, Harvey W. Preslan and Raymond A. Day, East Ohio Gas; Carl Howell, Washington Gas Light; Robert R. Dixon, Natural Gas Pipeline of America; William K. Holm, Texas Illinois Natural Gas Pipeline Company; John F. Dolson, Natural Gas of America. Fourth row: Thomas J. Quayle and Edward R. Rogers, Jr., East Ohio Gas; Richard F. Kruger, Brooklyn Borough Gas; B. Frank Harris, Consolidated Gas Electric Light and Power of Baltimore. In rear row are IGT Fellows, for whom the courses are required work in their studies for a master's degree: Ira E. Kanter, George N. Numsen, Richard W. Huffman, Ralph G. Zelmer, Eugene F. Witt, Richard N. Miller, George F. Field, Gerald J. Robertson.

PIPE LINE PROGRESS



A string of A. O. Smith line pipe on location during construction of the Interprovincial-Lakehead pipe line.

24-inch looping project to increase Interprovincial pipe line crude capacity

About 135 miles of 24-inch A. O. Smith line pipe is currently being lowered in to loop Saskatchewan and Manitoba section of 16-inch pipe in the Interprovincial Pipe Line. This will add capacity to a transmission system which, by December, will carry western Canadian crudes from the Edmonton, Alberta, area to Sarnia, Ontario.

Upon completion, this will be the world's longest crude oil pipe line, totaling 1738 miles from Redwater to Sarnia.

All the 20-inch and 18-inch pipe in the original line, presently terminating at Superior, Wisconsin, is A. O. Smith pipe. The 20-inch main runs from Edmonton to Regina; the 18-inch completes the run from Gretna, Manitoba . . . just north of the U. S. boundary . . . to Superior.

The present 24-inch installations are part of extensive looping of the 16-inch sector joining the 20 and 18-inch section.

Shipments were made from both Milwaukee and Houston mills, in supplying Interprovincial. A. O. Smith takes pride in its ability to meet delivery schedules, anywhere on this continent, with its high quality, internally expanded, welded line pipe.

A. O. Smith Line Pipe is available in a complete range of sizes and wall thicknesses, from 8⅝-in. to 36-in. diameters.

FIRSTS by A. O. Smith: Welded line pipe • Internally expanded pipe • Light-wall large-diameter pipe • World's largest producer of large-diameter welded steel pipe.

The A.O. Smith Casing Mill is operating at capacity to supply vitally needed casing for the Oil and Gas Industry.

A.O.Smith

CORPORATION

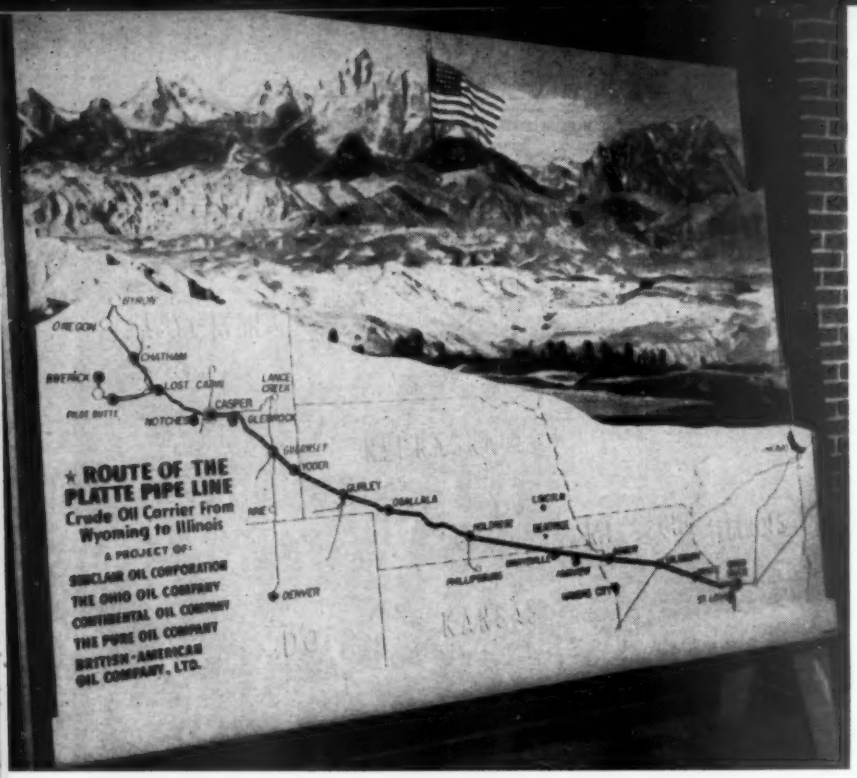
LINE PIPE • CASING

Chicago 4 • Dallas 2 • Denver 2 • Houston 2
Los Angeles 22 • Midland 5, Texas • New Orleans 12
New York 17 • Pittsburgh 19 • San Francisco 4
Seattle 1 • Tulsa 3 • Washington 6, D.C.

International Division: Milwaukee 1

DEPENDABILITY THROUGH RESEARCH AND ENGINEERING

Platte Pipe Line Dedication

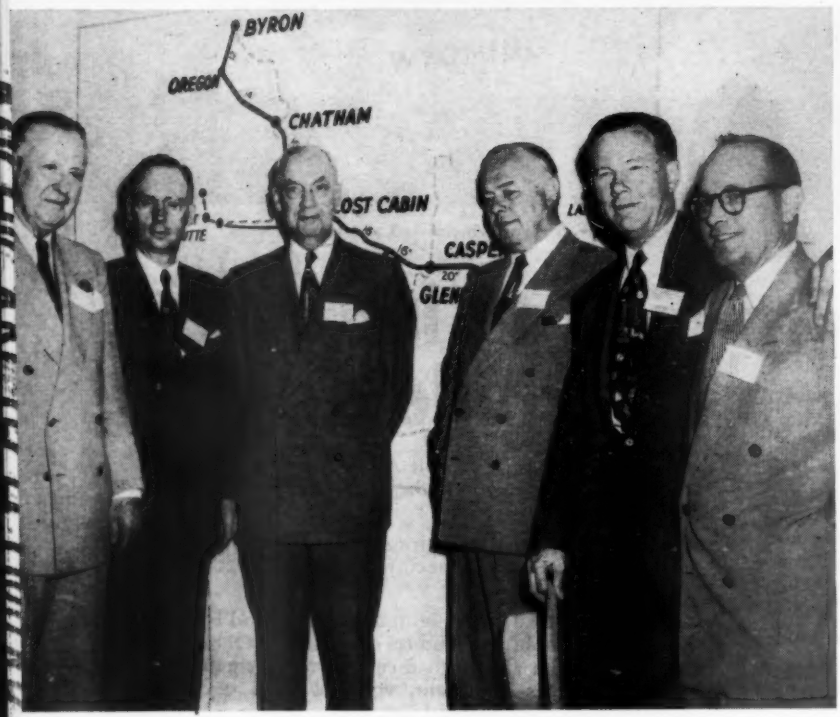


(Left) **ROUTE** of the 1149-mile crude carrier extends from northwest Wyoming to Wood River, Ill.

(Below, left) **PRESIDENTS** of the five owner companies join with Platte's chief executive. They are: P. C. Spencer, Sinclair; J. C. Donnell, II, Ohio Oil; L. S. Wescoat, Pure Oil; Ole Berg, Jr., British-American; L. F. McCollum, Continental Oil, and Millard K. Neptune, Platte president.

(Below, center) **FRANK M. PORTER,** API president, was feature speaker.

(Below) **MILLARD K. NEPTUNE,** Platte president, speaks at dedication.



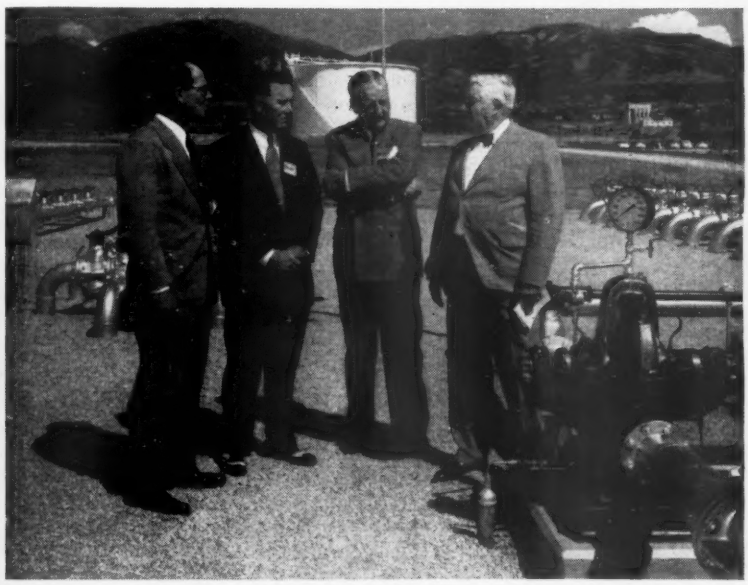
SENATOR HUGH BUTLER of Nebraska, Chairman of the Interior Committee, addresses dedication assemblage in Casper, Wyoming.

XUM

Pipeline Pictorial

Pioneer Pipe Line Dedication

(Right) **PIONEER** Pipe Line's route follows Weber River through Weber Canyon into great Salt Lake Valley. Pioneer line is first products pipe line to cross Continental Divide and traverses extremely mountainous territory. It crosses divide at 7120 feet and reaches its maximum elevation at Bear River Divide east of Evanston, Wyoming. Line profile descends about 3400 feet in its last 70 miles.



(Above, left) **INSPECTING** facilities of Salt Lake City terminal are E. C. Michels, Pioneer Pipe Line superintendent; L. F. McCollum, president, Continental Oil Company; P. C. Spencer, president, Sinclair Oil Corporation, and J. Reuben Clark, Jr., of the Presidency of the Church of Jesus Christ of Latter Day Saints.

(Above, right) **J. W. LIDDELL,** president of Pioneer Pipe Line Company, speaks at dedication ceremonies in Salt Lake City.

(Below, left) **GENERAL VIEW** of Pioneer Pipe Line Company's Salt Lake City terminal.

(Below, right) **W. R. ARGYLE,** Sinclair Refining Company vice president, unveils statue of the Pioneer Woman by Jo Davidson, famous American sculptor, at dedication ceremonies.

XUM

Pipe Line Personals

Harris Bateman, chief engineer for Cities Service Oil Company and Cities Service Pipe Line Company has returned to Bartlesville after completing a year's assignment with the Petroleum Administration for Defense as director of its Materials Division.

In addition to resuming the responsibilities of manager of the engineering division, his duties are being increased to include the activities of the purchasing, warehouse and surplus materials departments which are under the direction of Purchasing Agent **C. M. Taylor** and **H. D. Patridge.**

B. D. (Tex) Leuty, who has been supervising engineering division operations as assistant chief engineer during Bateman's absence, has been appointed manager of pipe line transportation. He will be in charge of both wholly and jointly-owned crude oil and products pipe lines. Leuty will be assisted in the joint-interest operations by **R. E. Roehl.**

Harry Nelson will continue as manager of Cities Service Pipe Line Company, the wholly-owned oil pipe line company.

Otto E. Zwanzig, formerly director of the bureau of statistics, has been appointed full-time director of the PAR Program of the American Gas Association. He also becomes secretary of the PAR Committee. Previously, the PAR activities were directed on a part-time basis by **John W. West, Jr.,** assistant managing director of AGA. West now assumes direct responsibility under the managing director for all headquarters activities other than the PAR Plan and those of the corporate secretary of AGA.

Daniel Parson has been advanced from senior statistician to director of the bureau of statistics, succeeding Zwanzig.

In his newly-created post, Zwanzig is responsible for the administration of promotion, advertising and research activities financed by PAR funds which currently amount to approximately $2,000,000 a per year. Appointment of a full-time AGA staff member to direct the PAR Plan was directed by the board of directors in accordance with recommendations made by the PAR reviewing committee headed by **R. J. Rutherford,** president, Worcester Gas Light Company, Worcester, Massachusetts.

C. C. Cragin, for 20 years vice president and general manager of El Paso Natural Gas Company, recently announced his resignation. Cragin will continue to serve El Paso Natural in the capacity of business and engineering consultant. **C. L. Perkins,** El Paso vice president, has been named general manager to succeed Cragin. Perkins has been with El Paso 24 years, serving as superintendent of gas treating, superintendent of the Jal division, transmission superintendent and assistant general superintendent. He was named vice president in 1944. **H. F. Steen** was elected vice president and general superintendent of El Paso recently. Steen has been superintendent of El Paso pipe line district, superintendent of Jal division, transmission superintendent and assistant general superintendent.

Other recent promotions in the El Paso company include **L. G. Sweatt,** named assistant compressor superintendent of the Permian division; **W. G. D. McElrath,** superintendent of operations for Utah Natural Gas Company; **O. B. Peacore,** superintendent of the Ehrenberg pipe line district; **T. J. Crutchfield,** compressor superintendent of the Permian division, and **N. W. Ray,** superintendent of the Deming pipe line district.

Earl W. Unruh, recently named part interest executive of Sinclair Pipe Line Company, has been elected vice president and director of Pioneer Pipe Line Company. Sinclair Pipe Line has a 35 per cent interest in the products pipe line system which connects Salt Lake City and Sinclair, Wyoming, location of Sinclair's refinery.

Charles J. Maisel has joined Tennessee Gas Transmission Company's Industrial Relations department as editor of "The Line," TGT's employee publication.

J. J. Dougherty, formerly at the Tomball office, has been named superintendent of Service Pipe Line Company's new Mineral Wells, Texas, district office. Assisting Dougherty at the new office will be **James R. Bird,** district clerk; **Hal McClintock,** division manager; **Paul T. Taylor,** division lineman, and **Marguerite Williams,** junior clerk.

T. A. van Griethuysen, Houston, coordinator of transportation and supplies for Continental Oil Company, has been elected a vice president by the company's board of directors. As vice president in charge of transportation and supplies, van Griethuysen will continue to direct Conoco's crude oil trading, transportation, purchasing and pipe line operations.

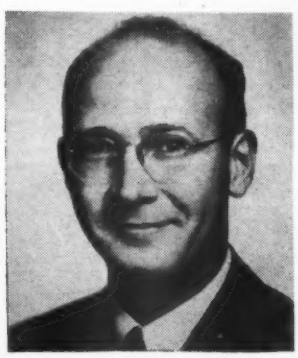
A native of Perkins, Oklahoma, and a graduate of the University of Oklahoma, van Griethuysen joined Continental in 1929 at Ponca City, Oklahoma. He served in the general accounting and personnel divisions before his promotion in 1932 to superintendent of the real estate department.

He transferred to the production department in 1935 and four years later was promoted to superintendent of Conoco's oil trading division, with headquarters in Ponca City. He was named manager of the crude oil trading department in 1948.

Van Griethuysen transferred from Ponca City to the company's executive offices in Houston in 1950, and last year was promoted to coordinator of transportation and supplies.

William J. Grove, Camp Hill, Pennsylvania, has been named assistant general counsel of the Federal Power Commission in charge of natural gas matters. Grove, at the time of his appointment to chief counsel of Pennsylvania Public Utility Commission, served from 1943 to 1949 as law clerk to Associate Justice Patterson of the Pennsylvania supreme court.

S. L. Digby, former Louisiana commissioner of conservation, has been affirmed by the Senate as a member of the Federal Power Commission. Term of the Monroe, Louisiana, attorney will last through June 22, 1958. He replaces former commissioner Herrington Wimberly. Digby, 61, a Democrat, completes the commission's panel of five members. He is a graduate of Louisiana State University, where he received a law degree.



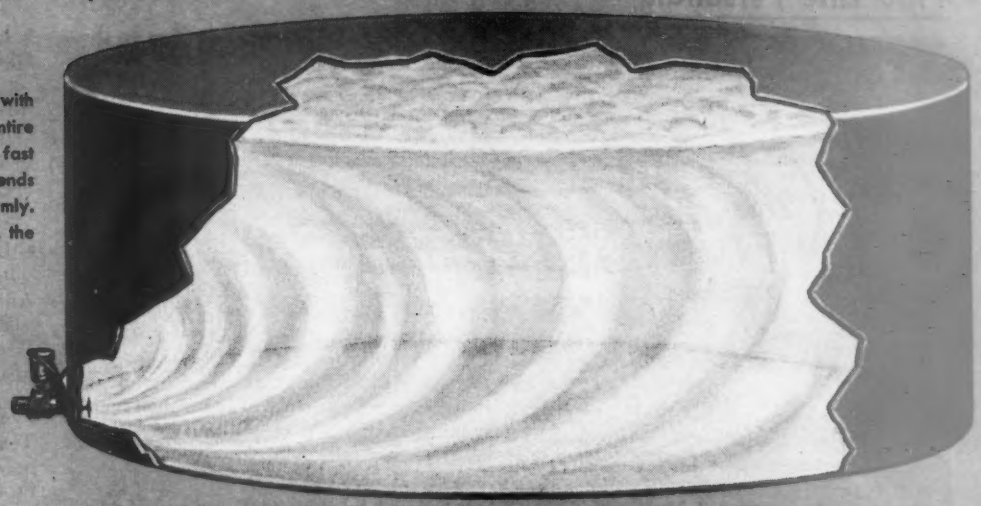
Right,
E. J. Brueggemann

Left,
Frank A. Boyd

E. J. Brueggemann, veteran of 29 years service with Gulf Oil Corporation, has been named manager of the Gulf tank car department. He will be located in the company's general offices in Pittsburgh, Pennsylvania.

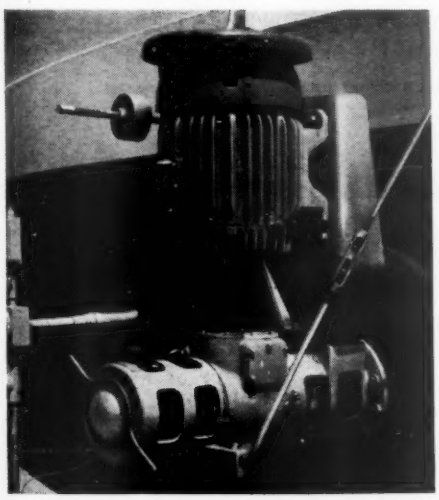
Frank A. Boyd has been appointed petroleum engineer in charge of Texas Eastern Transmission Corporation's Pittsburgh, Pennsylvania office. The Texas Eastern office was moved to the Alcoa Building in Pittsburgh September 1.

Boyd was previously a consulting geologist and engineer in Pittsburgh. He was graduated with a bachelor of science degree in petroleum and natural gas engineering from Pennsylvania State College, and did graduate work in the field of geology at Carnegie Institute of Technology.



NO SLUDGE BUILDUP in tanks equipped with LIGHTNIN Mixers. The mixer turns over entire tank contents gently but thoroughly, just fast enough to hold paraffin and other heavy ends off tank bottom and disperse them uniformly. Result: the stream leaving the tank contains the same values that entered the tank.

Say goodbye TO SLUDGE



LIGHTNIN SIDE ENTERING MIXERS—for tanks up to 6 million gallons capacity. Full range of sizes—1 to 25 HP. Gear drive (shown) or V-belt drive.

Get *full* tank capacity—all the time . . . save 5 to 10% on "dead storage" alone

If your pipe line operation is typical, you're losing 5 to 10% of your storage space from accumulated B S & W.

That isn't all. Downtime for cleaning out sludge costs you 3 to 5% of your tank capacity. This represents a whale of an investment—yielding no return.

Make your tanks work harder

You can stop these losses—for good—simply by using LIGHTNIN Mixers to hold heavy sludge components suspended in the crude.

You eliminate sludge buildup with LIGHTNIN Mixers. Even after long runs, tanks equipped with LIGHTNINS show no accumulation of bottom sludge.

Result—no more costly downtime for cleaning. Maximum storage capacity always available. The expense and mess of tank cleaning is eliminated. Valuable sludge components are recovered.

Rapid return on investment

You quickly recover the initial cost of installing LIGHTNINS in your tanks. Cases on record prove this. Users often show a profit *within a few weeks* after installing LIGHTNINS.

This guarantee protects you 100%

Your money back if LIGHTNIN Mixers are not satisfactory in every respect. This guarantee is backed by thousands of successful installations—at tank farms and in refineries, in tanks as large as 140,000 bbls.

For more profit, do this today

Your losses continue daily. The sooner you have all the facts, the sooner you can start turning these losses into profits. It costs nothing to find out what LIGHTNIN Mixers can save you, and does not obligate you in any way.

For full details, just fill in and mail the coupon. Do it today.

"Lightnin"® Mixers

MIXCO fluid mixing specialists

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Please send me, without obligation:

☐ B-503—New 4-page illustrated bulletin giving complete information on B S & W control and savings.

☐ B-104—New 20-page illustrated catalog containing full description, specifications and dimensions of LIGHTNIN Side Entering Mixers.

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Title_____

Company_____

Address_____

City_____ Zone____ State_____

XUM

Pipe Line Personals

G. H. Baird

George Harrison Baird, vice president, manager of operations and director of Cities Service Gas Company, has announced his retirement effective November 1, 1953, after a lifetime in the field of natural gas transportation.

Born in Valencia, Kansas, May 2, 1888, Baird attended grade school and high school in Shawnee County, Kansas, and graduated in 1914 from Kansas State Agricultural College with a BS degree in mechanical engineering. He began his career in the natural gas industry as a meter inspector, April 1, 1916, and was promoted successively to assistant superintendent, meter department; superintendent, meter department; division engineer; superintendent of operations; division manager; and on November 1, 1939 was elected vice president and manager of operations.

Although Baird expects to devote most of his future time and effort to the management of his ranch near Bartlesville, Oklahoma, Cities Service Gas Company will still have the advantage of his broad knowledge and experience in the natural gas business through his retention in a consulting capacity.

F. V. Cook, Service Pipe Line Company master mechanic, has returned to Tulsa from the Near East where he spent four weeks as consultant in diesel engine operation and maintenance on Trans-Arabian Pipe Line Company's 1050-mile Persian Gulf-Mediterranean line. **Melvin G. Morris,** Ranger, has been appointed division electrician at Levelland for Service.

Stanley Kleinheksel has been named assistant to the chief engineer, Eastern Pipe Lines division, Socony-Vacuum Oil Company. Dr. Kleinheksel will continue to supervise corrosion work and assist in direction of other engineering work. **Theodore S. Watson** has been named intermediate electrical engineer for the division and **John C. Santo** chief pump and engine mechanic.

Joseph L. Seger, president of Interstate Oil Pipe Line Company, has been named a member of the Transportation Council of the United States Department of Commerce for the year ending April 30, 1954. The invitation to accept the post was extended by Secretary of Commerce Sinclair Weeks.

Luther T. Dulaney, Oklahoma City, Oklahoma, manufacturer and distributor, has been elected to the board of directors of the Oklahoma Natural Gas Company. Dulaney, a native Oklahoman, began his business career in Oklahoma City in 1924 and is now head of a large concern.

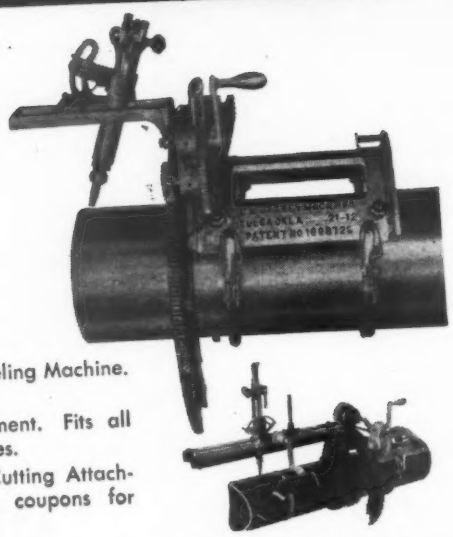
Richard H. Lamberton has been appointed midwest manager of the General American Transportation Corporation's plate and welding division. Lamberton is also serving as an assistant director of the Office of Defense Transportation.

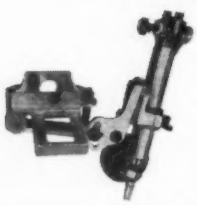
Allerton Miller, formerly secretary for Texas Gas Transmission Corporation, has been named vice president. **E. O. Stoothoff,** formerly assistant secretary, has been named to Miller's former position. **Franklin K. Rader, Jr.,** has been named assistant to vice president and treasurer **W. M. Elmer.** Rader was formerly supply contract representative. **Charles P. Moreton** has joined the company in Rader's former post.

Oil storage tanks that resist corrosion, electrolysis and fire are being made out of bolted, glass-reinforced plastic. The tanks weigh one-fourth as much as comparable steel tanks and are made in 250-barrel and 500-barrel sizes. At present, they cost about a fourth more than steel tanks.

*Mathey PIPE CUTTING AND BEVELING MACHINES

- QUICKEST IN OPERATION
  - Just slips over pipe
  - No hinges or latches to open or close
- LIGHTEST WEIGHT
- FIVE MODELS (for pipe from 4" to 36 inches)
- ECONOMICAL
- FOR RENTAL OR PURCHASE





Illustrated above: Mathey Pipe Cutting and Beveling Machine. Cuts pipe at any predetermined angle.

Illustrated left: Mathey Out-of-Round Attachment. Fits all sizes of Mathey (and Mathey-made) Machines.

Illustrated right: Mathey Shape and Coupon Cutting Attachment. For cutting pipe intersections and coupons for welding analysis.

*COMPLETE STOCKS OF PARTS FOR ALL MATHEY and MATHEY MANUFACTURED MACHINES IMMEDIATELY AVAILABLE

C. A. MATHEY MACHINE WORKS, INC.
212 SOUTH FRANKFORT ● TULSA, OKLAHOMA

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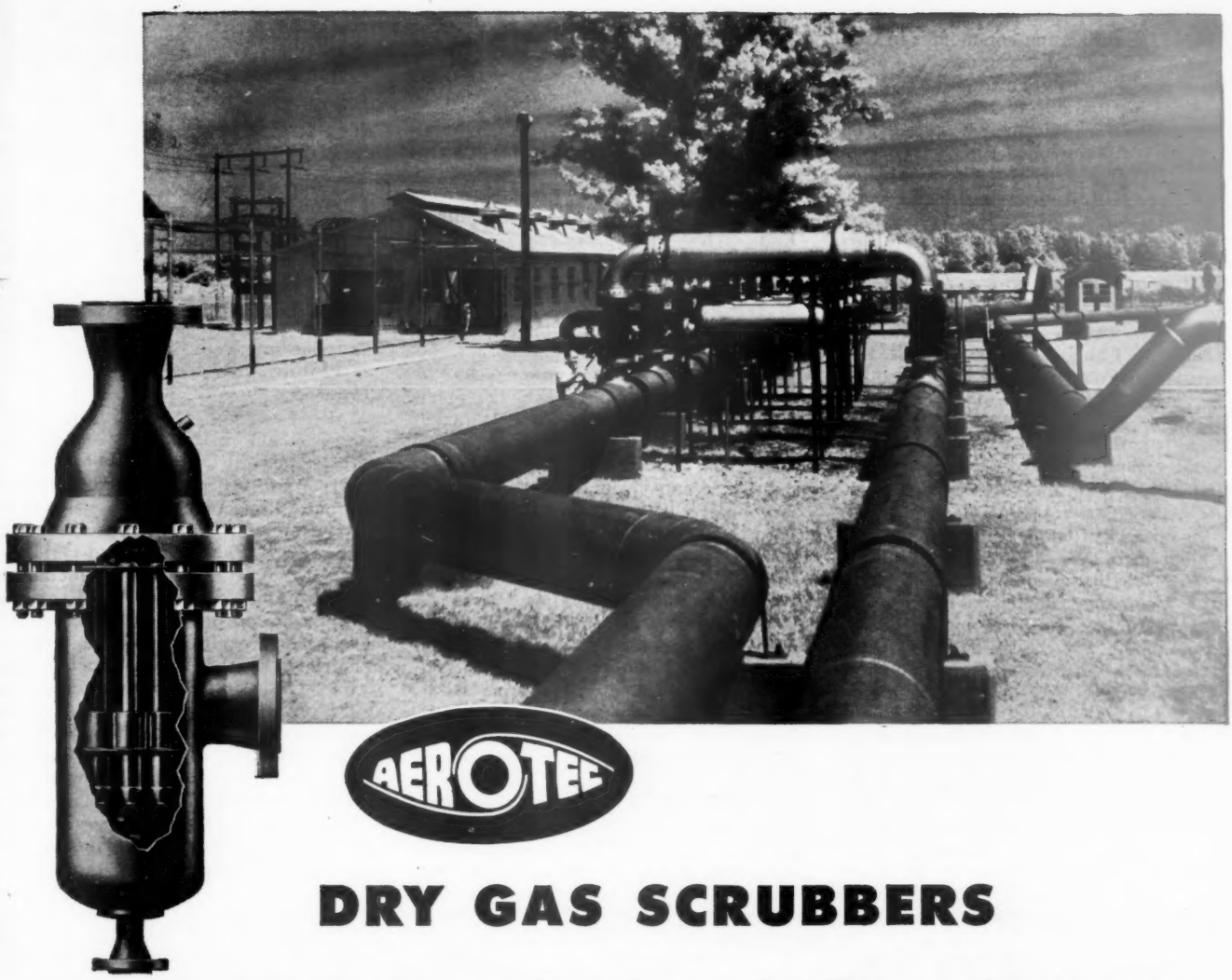

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DRY GAS SCRUBBERS

protect compressors and reduce pipeline maintenance

Dusts and distillates in natural gas put an unnecessary drag on profitable pipeline operation. Aerotec Dry Gas Scrubbers get rid of these damaging impurities with high efficiency, thereby reducing maintenance to a minimum. This is a proven fact in well and pipeline installations across the country.

The Aerotec Scrubber, unlike conventional types, uses no liquid filtering medium. Hence, you eliminate carryover of elements that cause compressor wear. You also avoid other difficulties normally encountered with wet-bath scrubbing methods. The Aerotec units assure clean, *dry* gas that flows freely and saves on repair and maintenance costs.

Basis of this efficiency is a unique method of scrubbing gas by the use of multiple, small-diameter tubes. Through the principle of dry separation by centrifugal force, foreign solids and liquids are precipitated, leaving the gas clean and dry.

Simplified piping permits easy installation of the compact, lightweight Aerotec Dry Gas Scrubber. Standard units up to 100,000,000 SCFD are available, with larger capacity requirements met by manifolding. For technical data and engineering assistance in selecting the Aerotec Scrubber best suited to your gas-cleaning needs, call or write our representatives today.

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Pipe Line Personals

Prominent Personages at the Platte Pipe Line dedication ceremonies in Casper, Wyoming, August 8, made up a list that reads almost like a "Who's Who" in the pipe line business, not to mention a host of other enterprises. Included on the guest list were **Ray Althouse,** executive vice president, Royalite Company, Calgary; **R. J. Andress** and **T. R. Aude,** vice presidents of Service Pipe Line Company, Tulsa; **Senator Frank Barrett,** Lusk, Wyoming; **Ole Berg, Jr.,** president of British American Oil Company, Ltd., Toronto; **Victor H. Bowman,** assistant vice president, The Pure Oil Company, Chicago; **Phil Bramwell,** vice president, First National Bank, Kansas City; **Reid Brazell,** president, Leonard Refining Company, Alma, Michigan; **Senator Hugh Butler,** Omaha, Nebraska, **James J. Cosgrove,** chairman of the board, Continental Oil Company, New York; **K. A. Covell,** vice president, The Pure Oil Company, Chicago; **G. L. Culver,** president, Plains Pipe Line.

A. A. Davidson, counsel, Sinclair Pipe Line Company, Independence, Kansas; **Ralph Dietler,** chairman of the board, Stanolind Oil Co., Tulsa; **James C. Donnell, II,** president, and **John R. Donnell,** treasurer, The Ohio Oil Company, Findlay, Ohio; **Fayette Dow,** National Petroleum Association, Washington, D. C.; **Warwick M. Downing,** Interstate Oil Compact Commission, Denver; **M. E. Foster,** president, Phillips Pipe Line Company, Bartlesville, Oklahoma; **Senator Dwight Griswold,** Council Bluff, Nebraska; **Congressman R. D. Harrison,** Norfolk, Nebraska; **Congressman Wm. Henry Harrison,** Sheridan, Wyoming; **Congressman R. L. Hruska,** Omaha, Nebraska; **Walter W. Hudson,** chairman of the Wyoming Public Service Commission, Cheyenne, Wyoming; **R. P. Huggins,** vice president, Gulf Oil.

David D. Irwin, former vice-president, The Pure Oil Company, Chicago; **Senator Lester C. Hunt,** Lander, Wyoming; **F. L. Jehle,** vice president, Globe Oil and Refining Company, Wichita, Kansas; **W. E. Jennings,** executive vice president, Buckeye Pipe Line Company, New York; **J. W. Jordan,** executive vice president, Sinclair Oil and Gas Company, Tulsa; **J. A. C. Kennedy, Jr.,** attorney, Omaha; **R. E. Kepke,** vice president, British American Oil Company, Ltd., Toronto; **W. C. Kinsolving,** president, Sun Pipe Line Company, Philadelphia, Pennsylvania; **Karl Koerper,** vice president, Kansas City P&L Company, Kansas City; **W. L. Kygar,** president, Continental Pipe Line Company, Ponca City, Oklahoma; **J. L. Latimer,** president, Magnolia, Dallas, Texas.

R. J. Luman, commissioner, Wyoming Public Service Commission, Cheyenne; **L. F. McCollum,** president, Continental Oil Company, Houston; **R. B. McLaughlin,** chairman of the board, Texas Pipe Line Company, Houston; **J. Howard Marshall,** vice president, Signal Oil and Gas Company, Fort Worth, Texas; **Joseph W. Meehan,** vice president, Pure Transportation Company, Chicago; **C. D. Miller,** executive vice president, British American Oil Producing Company, Dallas; **C. S. Mitchell,** president, Cities Service Pipe Line; **O. F.Moore,** vice president, Ohio Oil.

Harry Moreland, president, Great Lakes Pipe Line Company, Kansas City; **J. P. Moroney,** vice president, Colorado Interstate Gas Company, Colorado Springs, Colorado; **E. F. Morrell,** president, Mid-Valley Pipe Line Company, Longview, Texas; **W. H. Morris,** president, Sinclair Pipe Line Company, Independence, Kansas; **C. R. Musgrave,** vice president, Phillips Petroleum Company, Bartlesville; **C. C. Peppers,** president, Peppers Refining; **C. A. Perlitz, Jr.,** vice president, Continental Oil; **H. L. Phillips,** vice president, Sinclair Oil; **Frank M. Porter,** president, API, New York; **Governor C. J. Rogers,** Cheyenne, Wyoming; **J. H. Russell,** vice president, Gulf Oil; **W. M. Saxon,** Pure Oil; **Whtitney G. Sexton,** manager, Toronto Pipe Line; **W. E. Slaughter, Jr.,** president, Aurora Gasoline Company; **C. E. Spahr,** Standard Ohio.

P. C. Spencer, president, Sinclair Oil Corporation, New York; **A. W. Tarkington,** vice president, Continental Oil Company, Fort Worth; **R. J. Tibbets,** chairman of the board, Sinclair Pipe Line; **T. A. van Griethuysen,** vice president, Continental Oil; **L. S. Wescoat,** president, The Pure Oil; **W. K. Whiteford,** president, Gulf Oil; **Howard H. West,** secretary, Ohio Oil; **Joe C. Williams,** president, Commerce Trust Company; **Lynn Wolf,** executive vice president, Stanolind Oil; **D. A. Young,** president, Sinclair Crude Oil.

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PIPE CUTTING AND BEVELING MACHINE
Cuts and Bevels Pipe FASTER, MORE ECONOMICALLY
Split horseshoe shaped gear permits machine to slip quickly over pipe. Fast operating snap chain fasteners hold it in place. A complete cut and bevel can be made in a 12 inch pipe in about two minutes.
You'll soon save several times the cost of the machine in labor, gas and transportation charges. H&M takes approximately one-half the labor and gas to make the cut as hand cutting and the work is all done in the field.
Bring this light (24 to 155 pounds) but durable machine to the pipe instead of moving the heavy pipe to the machine. Remember, H&M designs for SPEED and ECONOMY.
Shape Cutting Attachment for cutting the various shapes of pipe intersections.
Out-of-Round Attachment is used when pipe is out of round.
See for yourself. Let us arrange a demonstration.
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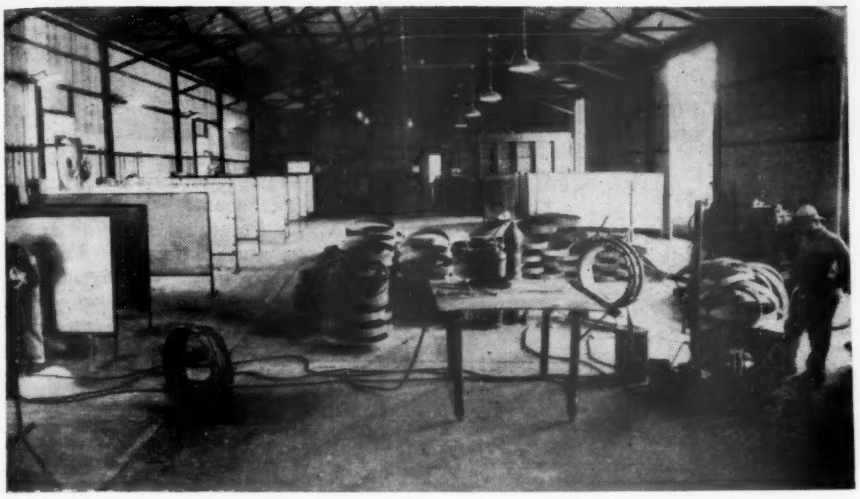


PIERCE welding school in Houston.

Welding School for Pipeliners Opened in Houston by Pierce

A school specializing in training welders for pipe line welding work has been opened in Houston by C. B. Pierce, for many years associated with pipe line contractors in supervisory capacities, and two associates, Carl Swint and Roy Pennell.

All types of welding, gas or electric, pipe line and industrial are taught in a complete 8-week program. The student works on new materials using the same equipment he will use later in his welding trade.

The school is housed in metallic building, and has seventeen welding booths for instruction. It is equipped with all sizes of beveling machines, grinders, six 200-amp vertical welders; six 300-amp horizontal welders; five gasoline driven 200-amp welders; and gas welding equipment. Students are provided with complete outfits and text books and a series of sound training films is used in the program.

AGA's 1952 "Gas Facts" Are Now Available

A number of tables containing new statistical material concerning the gas industry has been included in the 1952 edition of "Gas Facts," the yearly handbook of operating and financial information published by the Bureau of Statistics of the American Gas Association.

New statistics developed on underground storage are presented as a result of the work done by the AGA committee on underground storage. A third innovation is the initial presentation of indexes of weekly market prices, dividends and yields for the common stocks of thirty selected natural gas companies. These indexes were prepared by Moody's Investors Service and represent the first indexes based on a sufficiently large number of companies to be representative of the entire industry.

Data covering reserves, transmission, distribution, sales and utilization, financial results, construction expenditures, labor and prices again are included. Information published in "Gas Facts" has been submitted to AGA by companies representing over 94 per cent of customers, sales and revenues of the industry. Copies of this statistical handbook may be obtained at $1.00 per copy from the Bureau of Statistics at AGA Headquarters, New York City.

Texas-Arizona Line Contracts Let By El Paso Natural Gas

Contracts for construction of 567 miles of the new 771-mile, 30-in. gas line between Kingman, Arizona, and Plains, Texas, have been awarded to contractors by El Paso Natural Gas Company. Work on this section is to be completed by December 31.

Contractors include Oklahoma Pipe Line Constructors, 150 miles from Plains, Texas, to Corona, New Mexico; R. H. Fulton, 252 miles from Corona to Gallup, New Mexico; and Western Pipe Constructors, 165 miles from Flagstaff to Kingman, Arizona. El Paso's own crews will lay 204 miles of line across the Navajo Indian reservatiton.

Full Capacity Seen in 1954 For Trans Mountain Line

A minimum of 156,000 bbl per day will be moving through Canada's new Trans Mountain oil pipe line by the end of 1954, according to present estimates. That total will be made up of 56,000 bbl per day for Vancouver, British Columbia, refineries; 5000 bbl per day for a plant being built at Kamloops for Royalite Oil Company, Ltd., and 95,000 bbl per day for three refineries to be built in Washington.

Decision by Standard Oil Company of British Columbia, wholly owned subsidiary of Standard of California, to build a 11,000 bbl per day plant alongside its present 8250 bbl per day refinery raised the Vancouver throughput capacity estimate for 1954.

Possibility of a refinery to be built by British American in the Vancouver area would raise demand for Alberta crude oil movements to 70,000 bbl per day.

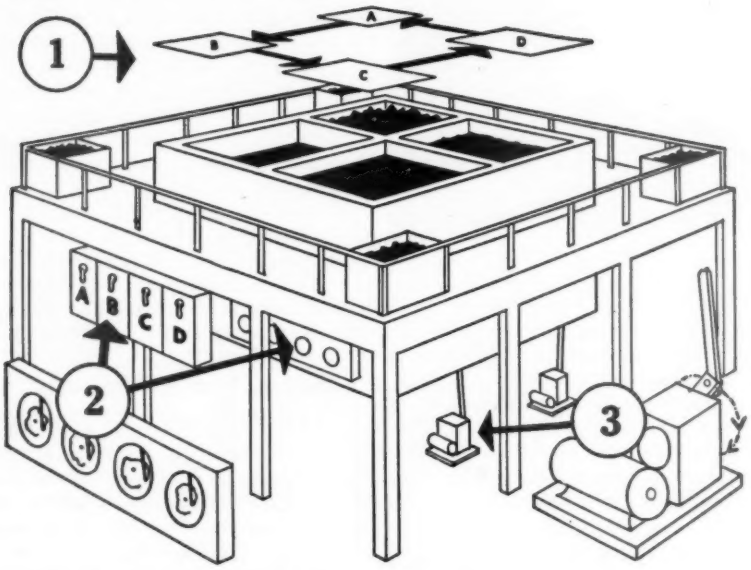
Texas Eastern Reports Progress In Construction; Earnings Down

In a quarterly report released to stockholders of Texas Eastern Transmission Corporation, R. H. Hargrove, president, said much progress of a constructive nature for the long range was made in the first half of 1953, although earnings during the second quarter continued at a depressed level largely because of unsatisfactory rates.

Transmission Corporation net income (unaudited) for the first six months of 1953 after provision for dividends on preferred stock amounted to $4,332,021, equal to $0.79 per share on the 5,499,027 shares outstanding. This compares with $5,490,794 for the first half of 1952, or $1.00 per share on the 5,498,677 shares then outstanding. On the same basis consolidated net income (unaudited) for the first six months of 1953 amounted to $4,088,057, equal to $0.74 per share, as compared to $5,262,681 or $0.96 per share for the same period in 1952.

CONSTRUCTION on Southern Natural Gas' new line is progressing rapidly. Pictured here are members of a H. C. Price Company team patching a break in the coating of the line prior to lowering in.

small batch kettles— another important *spi FIRST



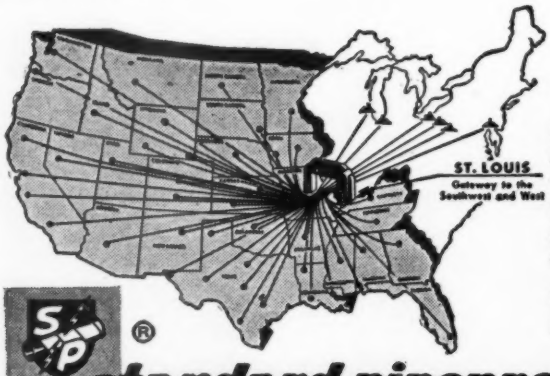
***standard pipeprotection inc.** designed and built a plant that was the first one equipped with small batch kettles to prevent alteration of the physical characteristics — softening point, penetration, and filler content — of the enamels, to assure performance of the enamels as formulated by the enamel manufacturers.*

① **FIRST** and only plant to melt 4-drum batches of enamels, one batch at a time, to prevent altering the physical characteristics. To secure a constant supply, a battery of kettles is fired in rotation, at short intervals, with reloading and refiring as emptied. A cycle from small cold lumps of enamel to complete consumption in less than three hours.

② **FIRST** plant to employ thermostatic temperature controls, with electric-eye flame controls and recording thermometers, to control the time and record the temperatures while melting the enamels to correct application temperature. These controls were the first used to prevent changes in physical characteristics of the enamels.

③ **FIRST** plant to provide mechanical cradle agitators for each kettle, to prevent sedimentation of enamel fillers added by the enamel manufacturers as a reinforcement for the bitumen.

The rotation firing of 4-drum batch kettles at Standard Pipeprotection Inc. prevents mixing different grades of enamels, and products of different manufacturers.



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Pipe Line News

Royalty Raise Declined By Trans-Arabian in Lebanon

A raise in the amount of royalties paid on Middle East crude flowing through Lebanon via the Trans Arabian Pipe Line has been turned down by officials of the pipe line company.

Premier Saeb Salam's suggestion that Trans Arabian readjust a royalty agreement of last May in favor of Lebanon was turned down by C. A. Swigart, company president. The May agreement increased Lebanon's annual royalty take by $23,000,000 annually, although that government has yet to ratify the raise.

Refusal to increase the royalty rate is credited to the fact that the Trans Arabian "Tapline" is experiencing severe competition from tankers that are operating at record postwar low rates.

Newest Oklahoma Station In Operation for Interstate

The newest station on Interstate Oil Pipe Line Company's Northern Division, located at Purcell, Oklahoma, has gone into full operation. The station, a booster on the Tussy-Maysville-Oklahoma City 12-in. line, is equipped with three 700-hp electric motors driving centrifugal pumps.

Surge Research Contract Granted Oklahoma A&M

Continuation of research at Oklahoma A&M College, Stillwater, Oklahoma, to develop a new method of analyzing flow in pipe lines is underway through a recent $115,000 contract given the school by a group of interested pipe line companies.

A three-year research program will be pointed at a study of pressure waves in pipe lines, commonly known as "surge," that necessitate the design of extra heavy lines.

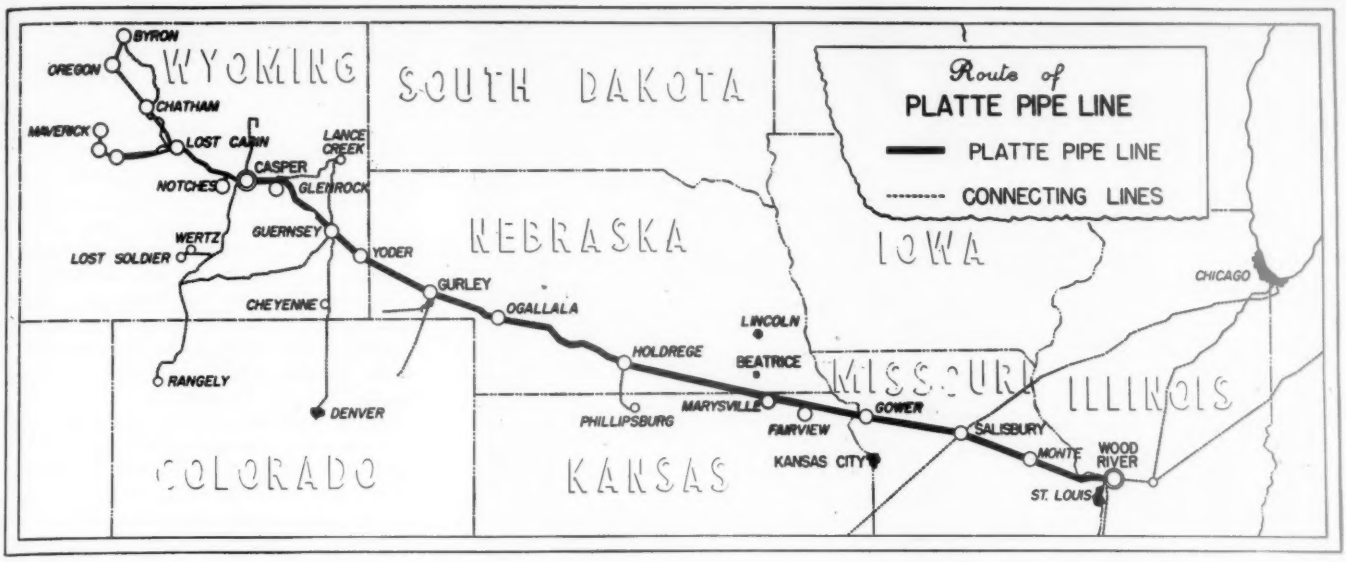
A full-scale, 2000-ft pipe line has been installed in the school's research laboratory for use in the expanded project. Dr. Clark A. Dunn, executive director of A&M's engineering research, said a four-member team would handle the research project.

FPC Rescinds Rules On Exporters of Gas

The Federal Power Commission has rescinded the two sections of its rules which interpreted its jurisdiction to include the transporters of natural gas for export to a foreign country, even though the facilities in this country were located within a single state.

The rule pertaining to the export of power provided that the ownership or operation of facilities for the transmission of natural gas from a point within a state to a foreign country makes one a "public utility" under the Federal Power Act even though the portion of such facilities in this country is located wholly within such a state.

Both rules have been in effect since June, 1945. The rescission of the two rules is effective immediately. Commissioner Dale E. Doty dissented.



ROUTE of the all-electric, 1149-mile Platte Pipe Line system crosses five states from origin to delivery teminals.

Casper Dedication Unveils Platte Pipe Line Operation

Dedication ceremonies held August 8 at Casper, Wyoming, "officially" placed the Platte Pipe Line in operation. The 1149-mile, 20-in. line, America's first all-electric major diameter pipe line for transporting crude oil, is capable of delivering 150,000 bbl daily of Rocky Mountain crudes from the western edges of Wyoming to Wood River, Illinois.

Among the speakers at the dedication were Frank M. Porter, president of the American Petroleum Institute, and Senator Hugh Butler, Omaha, Nebraska, chairman of the senate committee on interior and insular affairs. Millard K. Neptune, Platte president, presided over the ceremonies.

The new line, one of the largest and longest ever built in the United States, will make a market for excess Rocky Mountain crudes by providing transportation to central and midwest oil refineries. Present Rocky Mountain crude oil reserves which are in excess of 1,500,000,000 bbl are increasing as a result of stimulation the new line has given to exploration, development, and production in the area.

Five companies—The Ohio Oil Company, Sinclair Oil Corporation, Continental Oil Company, The Pure Oil Company, and The British-American Oil Company, Ltd.—joined forces in multiple ownership to build the common carrier line.

The 20-in. main line of 932 miles is augmented by a 126-mile, 16-in. spur extending from Chatham, Wyoming, to the main station at Casper, Wyoming, and 91 miles of 12-in. and 14-in. feeder line from the Big Horn Basin to Chatham. The line, serving an area recommended by the Petroleum Administration for Defense as requiring sizable pipe line transportation facilities, has a present transportation capacity of 110,000 bbl daily.

From the Big Horn Basin of Wyoming, the new line runs across Nebraska, northeastern Kansas, Missouri, and terminates at Wood River, Illinois, a major refining center as well as a junction point for connecting pipe lines to the East and North.

The main pump station at Casper is approximately a mile above sea level, and only four pump stations are necessary to provide the line with present delivery capacity to Wood River, some 4500 ft lower than Casper.

Three types of Rocky Mountain crude are gathered and transported in the line, and all three can be in the line at one time without mixing. Injection stations are operated by Platte at six locations in Wyoming, at Chatham, Pilot Butte, Notches, Casper, Glenrock, and Guernsey; and at Gurley, Nebraska, and Fairview, Kansas. In addition to Casper, main line stations are in use at Ogallala, Nebraska; Salisbury, Missouri; and Wood River. Five delivery points are currently maintained on the line, at Casper and Guernsey, Wyoming; Holdrege, Nebraska; Salisbury, Missouri; and Wood River.

The all-electric line includes a 44-station microwave system which provides nine channels for instant communication along the line from Casper to Wood River, and from Platte headquarters in Kansas City. By means of this system, it is possible in Platte's central headquarters to read and record pressures, to start and stop motors and pumps, to open and close valves, and to determine fluid levels in tanks at remote points on the line.

Almost 2,000,000 bbl of crude oil are required to fill the line, Platte operating officials said. Tankage for handling the crude oil on the line amounts to over 2,300,000 bbl.

Materials used in constructing the new line include 5946 railroad cars of pipe, enough to make up 100 train loads; 511 car loads of pipe coating for line protection were used; 102 car loads of casing to take up extra shock load at crossings; and 55 car loads of wrapping material, paper, and glass.

FROM THIS CONTROL ROOM in Platte Pipe Line Company's headquarters in Kansas City, Missouri, one man can supervise and control Platte's 1149-mile crude carrying pipe line from Wyoming to Illinois. The control panel's circular design allows operators to watch over all indicators by merely turning their chairs.

PIPE GANG pulls internal line-up rod from a joint of pipe as laying crew works on this road crossing operation Texas Eastern's new 307-mile Provident City-Castor line.

New 307-Mile Supply Line Completed by Texas Eastern

Texas Eastern Transmission Corporation has added 307 miles of 24-in. pipe in Louisiana and Texas to its main line. Designed to supplement and add flexibiliy to the supply end, this new pipe line increases the Texas Eastern system to some 4529 miles.

The new 24-in. pipe line originates at Provident City, Texas, southern terminus of Texas Eastern's 16-in. line. From this point it extends 307 miles in a northeasterly direction through Texas and Louisiana to a point of connection with the company's 20-in. pipe line on the north side of the Castor, Louisiana, compressor station.

The route of the pipe line crosses eight rivers—the Colorado, Brazos, Trinity, Neches, Sabine, Red, Angelina, and Attoyac. The Red River crossing is an overhead crossing and is under a long term lease from another pipe line company. All other crossings are underwater and except for the Attoyac, where one 24-in. was laid, two lines, a 24-in. and a 16-in. were laid under each river as a safeguard against floods.

The new line, which will enable Texas Eastern to obtain gas from the southwest Texas area, will be supplied at Provident City by Wilcox Trend Gathering System, Inc., a subsidiary of Texas Eastern.

Several new construction techniques were used in building the line. On casing seals at road and railroad crossings a newly developed method was used which consists of spraying on plastic to form an elastic seal. This new seal permits movement of the line, but remains watertight.

Another construction adaptation was used in the installation of valve ends. Texas Eastern ordered valve ends from the manufacturer complete with a 7-in. long forged steel transition piece, which equalizes pipe thickness at beveled ends and allows welder to do a better job.

The project was divided into four separate jobs, each handled by a different main line contractor. Construction office headquarters were at Lufkin, Texas.

Major subcontractors for pipe line spreads were Associated Pipeline Contractors, Houston; Anderson Brothers, Houston; Williams Brothers, Tulsa; and Trojan Construction Company, Oklahoma City. Subcontractors for the river crossings were: Pentzein, Inc., and Williams Brothers.

Houston-Port Arthur Line Completed By Sinclair

Completion of a wholly-owned 12-in. products pipe line from Houston to Port Arthur, Texas, has been announced by Sinclair Pipe Line Company.

The new 83-mile facility, which has a daily capacity of 54,000 bbl, will carry products from the Houston refining area to the Evangeline system now under construction from Port Arthur, Texas, to Baton Rouge, Louisiana. Sinclair Pipe Line Company is a part owner of the Evangeline System.

Completion of the 186-mile Evangeline system, which will connect with the existing Plantation Pipe Line at Baton Rouge, will make possible uninterrupted pipe line movement of petroleum products for more than 1500 miles from Houston through five southeastern states to Greensboro, North Carolina.

Construction of the new Sinclair line began last February. Testing operations are now in progress, and the line will be in service in early August. Williams Brothers Company, Tulsa, Oklahoma, was the contractor for the line. This latest addition increases Sinclair's wholly-owned products pipe line system to more than 3000 miles.

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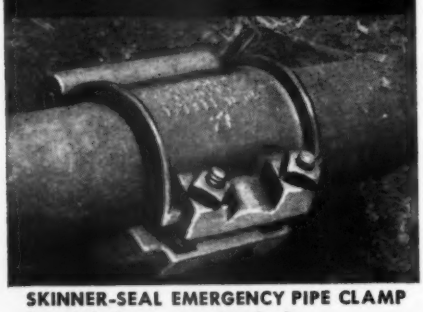

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Mineral Wells District Opened by Service Pipe Line

Service Pipe Line Company's expanding operations in west central Texas have resulted in a new district being established at Mineral Wells, according to F. M. Willenburg, Fort Worth, division manager.

The new district will be under the direction of District Superintendent J. J. Dougherty, formerly of Tomball. Offices are in the State National Bank Building.

Service Pipe Line Company, a common carrier of crude oil, has transported production from central Texas since 1919. The company expanded its gathering operations into Shackelford, Throckmorton and Stephen counties in the spring of 1951, and later expanded into Runnels, Coleman, Haskell, Knox and Stonewall counties.

Dougherty, transferred from the company's discontinued Tomball District, will have some 600 miles of trunk lines and three pumping stations at Mexia, Graford and Ranger, under his supervision. Ranger is currently pumping 15,000 bbl of crude oil south each day for eventual delivery to the Houston area, and 17,000 bbl to Graford. Graford pumps about 28,000 bbl daily of crude oil north to Bowie for eventual delivery to refineries in the Kansas City, St. Louis, and Chicago areas. Mexia pumps 10,000 bbl a day to Humble Pipe Line in Harris County.

Price to Coat Marine, Swamp Lines for Gulf Interstate

Gulf Interstate Gas Company of Houston has awarded a contract for the coating of 60 miles of 12 to 20-in. gathering lines on its system to the H. C. Price Company af Bartlesville, Oklahoma.

The coated pipe will be used at marine and swamp installations on the natural gas gathering system to be built by Gulf Interstate in southern Louisiana. The Somastic coating has been specified to provide protection against corrosion, while the Hevicote application will provide necessary additional weight for anchorage in the marine areas.

Included in the coating project are 17 miles of 20-in., 12.9 miles of 16-in., and 31 miles of 12-in. All of this pipe will receive applications of both Somastic and Hevicote at H. C. Price Co.'s Gulf Division plant at Harvey, Louisiana. The coating schedule calls for first pipe deliveries early in October.

Permian Basin Pipe Line Adding Three Stations

Three compressor stations on the 280-mile gas line system operated by Permian Basin Pipe Line Company between Yoakum County, West Texas, and the Spraberry Trend area, are under construction.

A total of 28 1320-hp units will be installed on the system. Three 1320-hp units will be placed at Plymouth station, eight 1320-hp units at Pembrook station and 17 of the units and dehydration facilities will be located at the Spraberry station.

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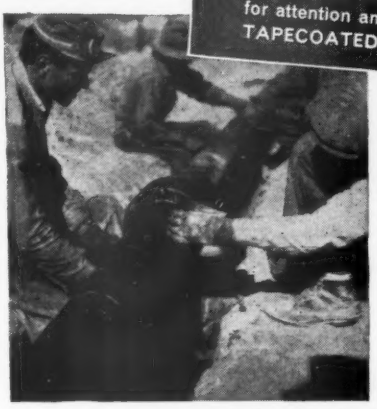
PROOF (Above ground)—A gas line at a bridge crossing was TAPECOAT-protected in 1944. There has been no need for attention and *no interruption of service* since the pipe was TAPECOATED.



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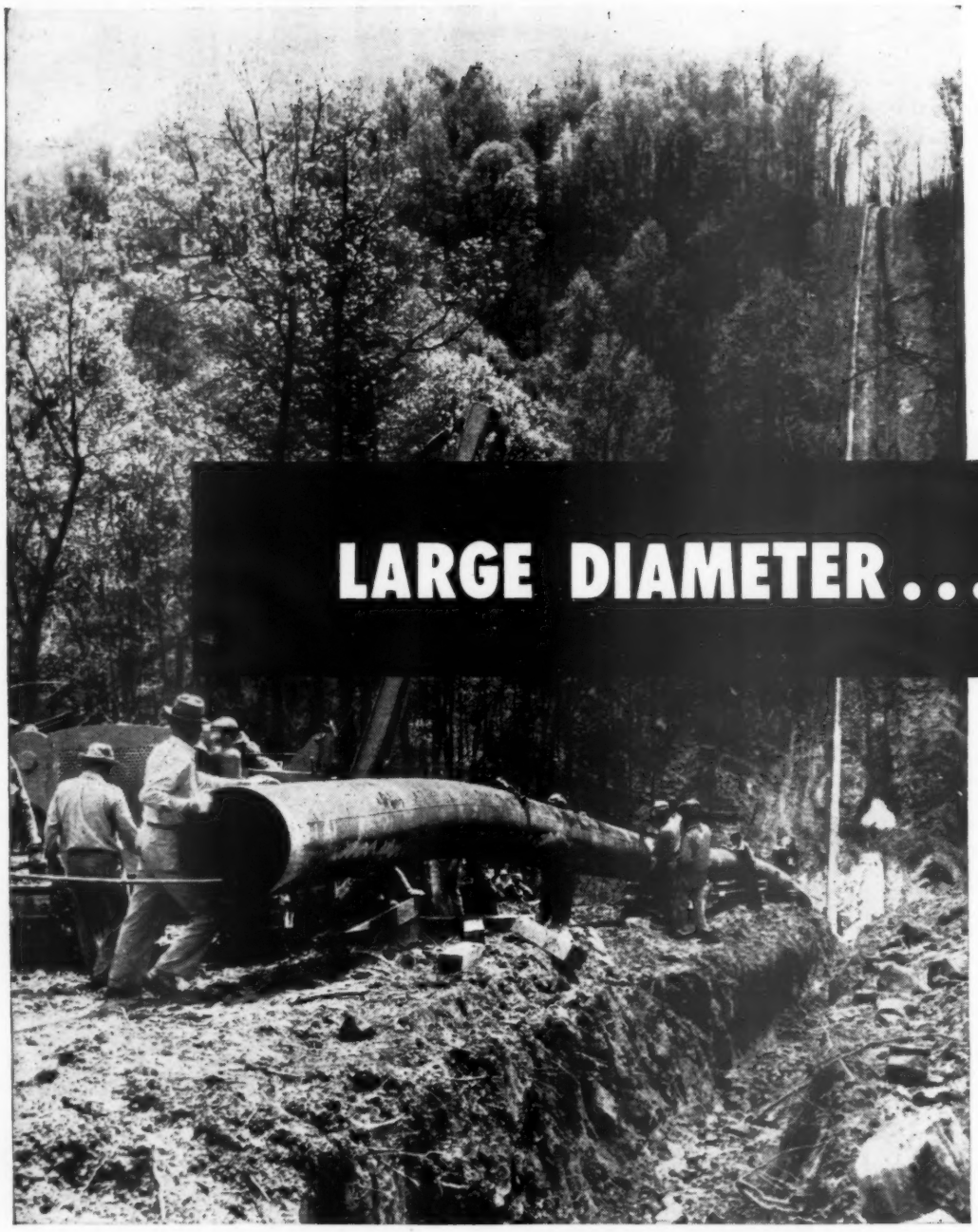

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High ductility assures smooth, uniform bends in the field or in the shop—without severe wrinkling. Uniform high yield strength permits building high pressure lines—and uniform wall thickness means dependability in every inch of the line.

Freedom from scale helps you get lines blown out and on-stream in short order . . . with least worry about clogged valves from scale loosened in service.

Republic Electric Weld Line Pipe . . . electric resistance weld from 2⅜" to 16" or electric fusion weld from 24" to 30". . . helps maintain laying schedules, helps maintain service on over 67,000 miles of transmission, gathering, distribution and product lines. Write for literature to:

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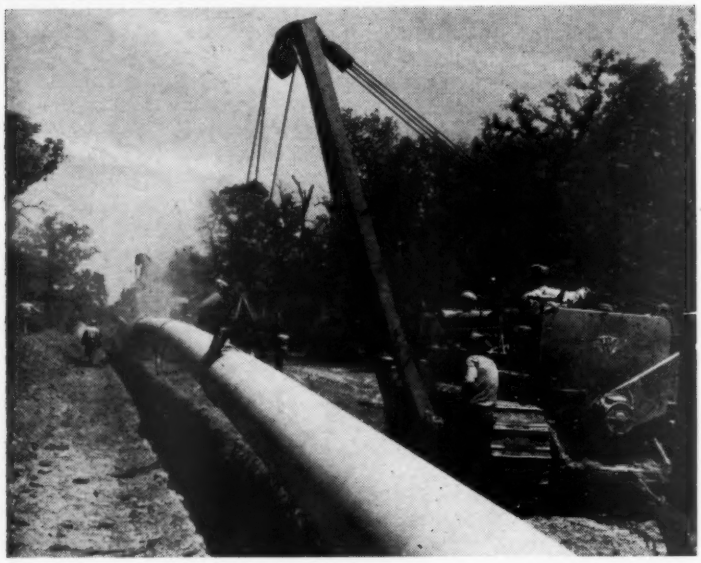

COATING and wrapping machine applies hot tar enamel, fibre glass and heavy paper to Texas Eastern's new 24-in. line.

WELDERS run a stringer bead during construction of a gathering line for Wilcox Trend Gathering System, Inc., of Dallas, Texas.

History of Price Construction Reflected In Huge Plastic Map

An accumulated record of nearly 22,000 miles of pipe line construction are reflected on a large plastic map, engraved with the routes of many of the nation's major oil and gas pipe lines, now on display at the headquarters office of the H. C. Price Company in Bartlesville, Oklahoma.

The 54-in. by 80-in. map, edge lighted with neon tubes, was a feature of the Price company's exhibit at the recent International Petroleum Exposition in Tulsa.

Colored lines have been engraved on the back face of the plastic to indicate various construction activities undertaken by the Price organization during its 30 years of service to the pipe line industry.

Dash lines, showing current construction by Price spreads, are filled in as new work is completed. Most outstanding of current projects is the Gulf-Interstate pipe line, with Price and Houston Contracting Company sharing the construction of approximately 860 miles of a 30-in. line which will carry gas from southern Louisiana into eastern Kentucky.

AGA Safety Awards to be Presented at New York Meeting

One hundred gas companies will be presented with awards for outstanding accident prevention work at the fifth conference sponsored by the Accident Prevention Committee of the American Gas Association at the Statler Hotel, Buffalo, New York, on September 17. A. Sidney Hancock, director of safety, Long Island Lighting Company, Mineola, New York, is chairman of the AGA Accident Prevention Committee.

Top awards will be presented to the ten companies having the best accident prevention experience in 1952 in a classification of companies as to size. Additional awards will be made to 90 companies who reduced the frequency of accidents 25 per cent or more in 1952 as compared with 1951.

Low Tanker Rates Threaten Future of "Tapline"

A gloomy economic future faces the $230,000,000 "Tapline" in Arabia because of low rates being offered by operation of super-tankers in the Arabian area.

The trans-Arabian pipe line operated by Aramco is feeling a competitive pinch due to an increased number of tankers operating between the Persian Gulf and the Suez Canal zone. Some tanker rates are as low as 30 per cent below the U. S. Maritime Commission rate. Tanker rates ranging 10 per cent or below the USMC rate mean haul by tanker is cheaper than pipe line transportation.

Tapline officials have admitted a 15 per cent decline in deliveries from peak operation of the pipe line.

Cold Weather Welding Aided By New Mask Attachment

An attachment to a conventional welder's mask for cold weather operation has been developed by Curtis L. Olson, deputy chief of the mechanical equipment branch at the army's Engineer Research and Development Laboratories, that are at Fort Belvoir, Virginia.

Olsen's development, easily attached to a conventional mask or hood, is designed to prevent the lens on the mask from frosting in freezing temperatures. Present masks frost in cold weather and make operation of welding equipment difficult.

The new attachment can also be applied universally. Tests have indicated that it also improves operator comfort in hot weather since its ventilating effect provides for the removal of stale air and welding fumes from inside the helmet.

WELDERS put a stringer bead on a section of pipe as laying crew lies up the next section of pipe during construction of Texas Eastern's new 307-mile Provident City-Castor 24-in. main line.

CONSTRUCTION crews tie-in piping at Wilcox Trend Gathering System compressor station near Thomaston, Texas. Compressor station has an installed horsepower of 2200.

228-Mile Wilcox Gas System Placed in Operation in August

Wilcox Trend Gathering System, Inc., has begun operation of a project involving 145.4 miles of main line, 82.8 miles of lateral line and one 2200-hp reciprocating compressor station. The system, completed in August, has a designed delivery capacity of 125,000,000 cu ft of gas per day.

The new main line begins at the Hagist Ranch gas field in Duval County, Texas, and extends in a northeasterly direction through McMullen, Live Oak, Bee, DeWitt and Lavaca counties to a connection point with Texas Eastern's 24-in. line at Provident City, Texas.

All main line construction, including one river crossing operation, was handled by the H. B. Zachry Company, San Antonio. Of the 145.4 miles of main line, 68.4 miles is 16-in. and 77 miles is 14-in. pipe. Two lines were laid across the Guadelupe River, one concrete-coated 16-in. line and one 12-in. line with river weights.

Altgelt Construction Company, Inc., Corpus Christi, handled construction work on the 82.8 miles of lateral and gathering facilities, composed of 5.3 miles of 8-in. laterals, 26 miles of 6-in. laterals, 18.6 miles of 4-in. laterals, and 32.9 miles of 3-in. laterals.

These gathering facilities provide for the gathering of gas from the following fields: Hagist Ranch, Loma Alta, Rhode Ranch, Clay West and Tom Lyne, Maxine, South Karon, North Karon, Rudman, and Maley, Minoak, North Minoak, West Yoward, Yoward, Goree, North Mineral, San Domingo, and Strauch Wilcox, West Cosden, Dial, South Runge, Angel City and Riverdale, Nordheim, Henze, Brandt Field Extension, Meyersville, Cottonwood Creek, and Arneckeville.

The design of the system conforms with or exceeds the provisions of the American Standard Association code for pressure piping. The lines were hydrostatically tested to a safety factor well above planned operating pressures.

Rate Increases Granted Two Companies by FPC

Rate increases to two firms, United Fuel Gas Company of Charleston, West Virginia, and Texas Gas Transmission Corporation, have been approved by the FPC.

Increases in rates totaling approximately $10,000,000 were allowed United Fuel, a subsidiary of Columbia Gas System, Inc., covering in effect two rate increases collected under bond by United Fuel since August, 1951. The company filed a rate increase in August, 1951, of approximately $7,200,000 and an additional increase of approximately $6,900,000 in February, 1953, both collected under bond. The FPC ruled the first rate increase need not be refunded, but a refund of about $3,000,000 per year would be necessary under the second rate increase.

Texas Gas has been granted an increase in wholesale rates which would produce approximately $8,500,000 per year, based on sales of a 12-months period ending October 31, 1952. The settlement accepted by the FPC does not change the rates of Texas Gas' subsidiary companies, Texas Northern Gas Corporation and Louisiana Natural Gas Corporation.

Pipe Line Corrosion Forum To be Held in Tulsa by NACE

An open session of a technical practices committee, a Pipe Line Corrosion Forum and three symposia will be held at the meeting of the South Central Region of the National Association of Corrosion Engineers to be held October 7-9 at the Mayo Hotel, Tulsa, Oklahoma.

Technical Practices Committee No. 1 on Corrosion of Oil and Gas Well Equipment will open its meeting to all registrants who are interested in the work and findings of the committee. Three symposia have been arranged: Oil and Gas Production Symposium, Processing Plant Symposium, Oil and Gas Transportation Symposium.

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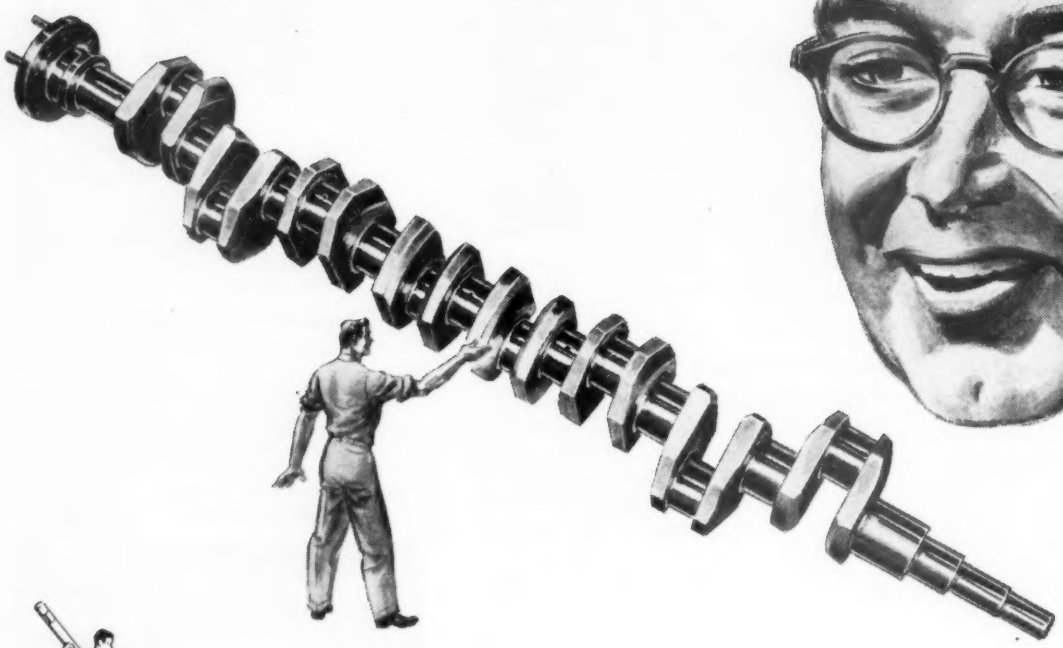

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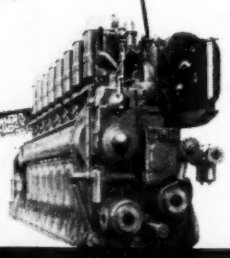

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Pipe Line News

Last Lap of 718-Mile Line Underway by Trans Mountain

Construction crews working on Trans Mountain Oil Pipe Line project are on the last lap of the 718-mile system between Edmonton, Alberta and Vancouver, British Columbia. Oil is expected to start flowing through the line early in October, company officials report.

A scraper trap is under construction at Sumas. The scraper trap is necessary because there is a wax content in some Alberta oils. Wax adheres to the inside of the pipe and must be removed periodically by scrapers passing through the line.

Nearly 1,000,000 bbl of oil are now in storage at Edmonton tank farm preparatory to filling the line. Pump stations have been tested at Edmonton and Kamloops. Burnaby tanks will be completed by October 1. Contracts for painting tanks at Burnaby have been let and work is underway. Tanks will be painted green to blend with the landscape.

Seeding of Burnaby tank farm is well underway with about 35 acres completed to date, and the grass is showing strong, healthy growth. Work is progressing rapidly on Westridge deepsea terminal on Burrard Inlet. This unit will be completed by October 15.

Canadian Line Proposed

Northwestern Utilities, Ltd., Edmonton, and Canadian Western Natural Gas Company, Ltd., Calgary, have applied to the Alberta conservation board for permission to build an $8,500,000 natural gas pipe line connecting Edmonton and Calgary. The proposed line would serve intermediate cities and aid in the development of fields along its route.

Mexican Line Operating

A 125-mile crude pipe line between Jose Colomo field in Tabasco state and El Plan in Veracruz has begun operation. The new Mexican line is expected to aid in developing full production of Jose Colomo field.

Deepest Underwater Pipe Line Is Laid

The deepest under-water crossing of a large diameter pipe line was completed across the Straits of Mackinac in mid-August after a broken winch delayed the job several days.

A 20-in. line, part of the Lakehead Pipe Line Company's current construction program, was divided into eight 2500-ft sections for the pull between Michigan's two peninsulas.

Storage of natural gas underground during the summer months to be withdrawn in winter months continues as an important phase in gas industry economics. The gas industry will spend $38 million for new underground storage in 1953 and devote more than $134 million in the next four years.

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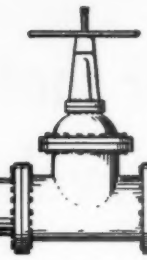
PIPE LINE PROJECTS



Canadian Gas Service Race Gets Third New Contestant

A third company has joined in the race to carry surplus Alberta natural gas to points east. Mid-Continent Pipe Lines has filed application with the Alberta conservation board to build a natural gas pipe line to eastern Canada from Big Valley, and would also build branch lines to Edmonton and Fort St. John, and to Pincher Creek from Big Valley.

Mid-Continent's proposed main line would go through Saskatchewan and Manitoba, cross the international boundary at Emerson, Manitoba, through the United States via Duluth, Minnesota, returning to Canada at a point in Michigan near Sault Ste. Marie. Across the border, lines would go to Sudbury, North Bay, Huntsville, the Toronto-Hamilton area, Ottawa, and Montreal.

Other companies seeking permission for trans-continental gas service in Canada are Trans Mountain Pipe Line, which would build an all-Canadian route, and Western Pipe Lines, which would build into the Central states and continue to eastern Canada after a five-year interim period.

Mid-Continent proposes to take nearly 550,000,000 cu ft per day in its fifth year of operation and 3.5 trillion cubic feet over a 20-year period. The company proposes to sell 100,000,000 cu ft per day to Northern Natural Gas Company near Duluth. This would be necessary to assist in the lower unit cost.

Cross-Canada Gas Line Would Cost $290,000,000

Total cost of constructing a naural gas pipe line from Alberta to eastern Canada has been estimated at $291,059,000, Western Pipe Lines, Ltd., has estimated. That figure was presented on behalf of the pipe line company at hearings of the Alberta conservation board by E. J. McConnell, New York, of Stone and Webster Service Corporation.

Construction of the line would necessitate two phases, one from Alberta to Winnipeg including a gathering system, at a total cost of $86,409,000, and would be completed in four years.

Work on the second phase would begin after completion of the first, and would consist of a line east from Winnipeg to Brooklin, Ontario, branching at that point to Montreal and Toronto. Cost of the second phase if $204,650,000 and would take an additional three to four years for completion. Flow of gas through the line would start before all points were completed, however.

Estimates of cost, stressed McConnell, are based on present costs of materials and labor and could conceivably go higher.

Design of the Western Pipe Line system calls for 24-, 26-, and 30-in. pipe. From Alberta fields to Winnipeg, a 30-in. line would be built. From Winnipeg to Toronto, a 26-in. line is planned and a 24-in. line to Montreal. Lateral lines would connect the main line along the route to communities wanting gas service. A total of 21 compressor stations will be built along the line.

$5,000,000 Union Oil Terminal Underway

Construction has started on a $5,000,000 marine oil terminal for Union Oil Company at Rodeo, Contra Costa County, California, to handle increasing cargoes of crude petroleum and refined products at its Oleum Refinery.

The project will require 10 to 12 months for completion, company engineers have estimated. Construction includes a concrete and steel wharf for two tankers, extending 1900 ft from the shore, 1250 ft long and 136 ft wide. A two-lane causeway will connect it with the shore and a concrete office building will be constructed on the wharf.

Pipe line system of the wharf is designed to handle up to 500,000 bbl per day. All pumps will be shore installations and 31 pipe lines will be laid for movement of crude oil and products.

Contractor for construction of the terminal is Ben C. Gerwick, Inc., San Francisco, and structural design by Earl and Wright, San Francisco.

Algonquin, Northeastern Get Approval on New England

FPC approval has been granted Algonquin Gas Transmission Company of Boston, Massachusetts, authorizing completion of that company's pipe line system and commencement of natural gas service in New England. Northeastern Gas Transmission Company of Springfield, Massachusetts, has also been granted a certificate to extend its system to serve additional markets in New Hampshire, Maine and Massachusetts.

Under the FPC order, Texas Eastern Transmission Corporation of Shreveport, Louisiana, will sell natural gas to Algonquin and Tennessee Gas Transmission Company of Houston, Texas, will increase its deliveries to Northeastern to enable the latter company to serve its new markets.

Previous FPC authorization allowed Northeastern certain markets in Massachusetts, Connecticut, and New Hampshire. Algonquin was granted market areas in Connecticut, Massachusetts, Rhode Island, and New Jersey.

Contract Awarded on Canadian Construction

Canadian Pipe Line Construction, Ltd., has been awarded the contract for construction of 32 miles of 16-in. main line loop between Calmar and Edmonton for Texaco Exploration Company.

Work on the lines is expected to be completed sometime in September. The addition to the Texaco pipe line system completes a 38½-mile loop into Edmonton and makes it the largest diameter field line in Canada. Gravity flow capacity will be 47,000 bbl per day and ultimate pumping capacity 110,000 bbl per day.

Construction Started On New North Dakota Products Line

Construction on all sections of North Dakota's first products pipe line has been started by Standard Oil Company, R. E. Nelson, Jr., general manager of crude oil supply and products pipelines, announced. The 10¾-in. diameter line will run 205 miles from Mandan, North Dakota, to Moorhead, Minnesota, providing an outlet for the Williston Basin crude oil to be processed in the refinery Standard is building at Mandan.

The line will connect with Standard's other products pipe lines in eight midwestern states, providing greater flexibility in the company's distribution. Its completion will bring the total length of Standard's products pipe lines to 2174 miles.

While completion of the Mandan refinery is scheduled for October, 1954, the new line is expected to be ready for operation by December 1, 1953. From then until the refinery is finished, temporary pumping facilities at the company's Moorhead terminal will move products westward through the line to Mandan.

When the new refinery is completed, the pipe line flow will be reversed. An origin pump station will be built at the Mandan refinery and an intermediate station near Jamestown, North Dakota. The new line will carry gasoline, kerosene, heater oil, furnace oil, power fuel, and diesel fuels.

The Mandan pump station will dehydrate the products before they enter the pipe line, minimizing internal corrosion. Gate valves will be placed strategically along the line to isolate particular sections, if necessary. The new pipe line will be patrolled by airplane.

Contractors on the line are Associated Pipe Line Construction Corporation, working on about 202 miles of line; Pentzien, Inc., about 2.6 miles of line including the Missouri River crossing; and J. L. Cox and Son, pipe hauling and stringing on the 202-mile section.

1000-Mile Gas Line Planned Between Louisiana, Wisconsin

Plans for a new 100-mile natural gas pipe line to suply markets in Michigan and Wisconsin have been made by American Natural Gas Company. The new line, a subsidiary of American Natural, will operate under the name of American Louisiana Pipe Line Company.

Permission to form the new subsidiary has been applied for from the Securities and Exchange Commission. Total cost of the American Natural expansion program, including extension of distribution facilities in the service territories, is estimated at about $200,000,000.

Constructon of the new line will make available the reserves of Louisiana Gulf Coast natural gas to system distributing companies. The gas has been obtained through purchase agreements with Stanolind Oil and Gas Company and Superior Oil Company.

An application to the Federal Power Commission is expected to be filed in September for the necessary certificate to build the line. Initial capacity of the line will be between 250,000,000 cu ft and 300,000,000 cu ft daily. Later expansion may bring that figure to 550,000,000 cu ft per day.

Additional storage fields recently acquired in Michigan, which more than doubles potential storage capacity to a total of 110,000,000,000 cu ft, will make possible operation similar to that conducted successfully in the past few years by American Natural's Michigan-Wisconsin Pipe Line Company subsidiary.

Financing of the project will be on a step by step basis, William G. Woolfolk, company chairman, has stated. Necessary funds are expected to be raised through issuance of senior securities of the various operating units, through retained earnings and sale of about $25,000,000 of additional common stock.

Army to Build Alaska Products Pipe Line

An 8-in., 600-mile products pipe line between Haines and Fairbanks, Alaska, crossing northwestern British Columbia and the Yukon, will be built by the United States Army, the Canadian external affairs department has announced. U. S. Army Engineers will build the line.

Negotiations covering construction of the line were recently completed by the U. S. and Canadian governments after a year's discussion. The new line is expected to play an important part in meeting military requirements of petroleum products by forces based in Alaska.

Canadian military needs in the northwest will also be aided by the new line, and civilian needs will be filled when the pipe line is not required for military purposes.

Cost of the line will be approximately $40,000,000 and some $12,000,000 will be spent on the Canadian section. Route of the line will follow the Haines cutoff, a military road from Haines to Haines Junction on the Alaska highway and then north along the highway to Fairbanks.

British Columbia and the Canadian federal government will retain title to right-of-way in Canada, some 284 miles. The external affairs department said the United States would be given a 20-year right-of-way easement.

September Rehearing For Mississippi

The FPC has set September 28 as the date for rehearing of an FPC order denying a proposal by Mississippi River Fuel Corporation, of St. Louis, Missouri, to supply natural gas on an interruptible basis to Union Electric Company of Missouri.

New Compressor Station, 17-Mile Line Requested

Texas Eastern Transmission Corporation of Shreveport, Louisiana, has filed an application with the Federal Power Commission requesting authority to construct approximately 17 miles of pipe line and a new 4400-hp compressor station in Texas to enable it to transport additional quantities of natural gas into its main transmission system.

The company said that it has entered into contracts to take about 1,000,000 cu ft of gas daily from the Englehart field in Colorado County, Texas, 10,00,000 cu ft from the Big Hill field in Jefferson County, Texas, and an additional 10,000,000 cu ft daily from Wilcox Trend Gathering System, Inc., as well as additional supplies elsewhere on its own system.

The proposed new construction program, estimated to cost about $1,981,900, would include a 5.3-mile, 6-in. lateral line from the Englehart field to a point of connection with Texas Eastern's Provident City Caster line; an 11.5-mile, 8-in. lateral from the Big Hill field to a point of connection with the Texas Eastern's Provident City-Beaumont line; and a 4400-hp compressor station in Shelby County, Texas, on the Provident City-Castor line.

Iowa Products Terminal Construction is Started

A distribution terminal to serve most of eastern Iowa has been started near Ottumwa, Standard Oil Company has announced. The terminal will receive gasoline and fuel oil from the company's 12-in. products pipe line recently built from its Sugar Creek, Missouri, refinery to Dubuque, Iowa.

Scheduled to begin operating the first of next year, the terminal will supply an area from the Mississippi River west to Des Moines, and from south of Cedar Rapids to north Missouri. Working two shifts daily, the terminal will be able to handle some 1,000,000 bbl a year with four tanks. It will also have an operations building, loading docks, and driveways. The company said the terminal will be built with safety precautions higher than those required by the state.

Southern California Line Authorized

The Federal Power Commission has issued a certificate authorizing Southern Counties Gas Company of California, of Los Angeles, California, to construct approximately 14 miles of pipe line to provide additional capacity to meet increasing demands in Orange County, California.

The proposed project will include about 72,000 ft of 24-in. pipe and 1000 ft of 22-in. pipe extending from a point on the company's existing 30-in. Blythe-Santa Fe Springs pipe line near Brea, to Santa Ana, California. Estimated cost of the new facilities is $879,962.

FPC Gives Approval To Panhandle Eastern

A decision has been led by presiding examiner Marvin Farrington of the Federal Power Commission authorizing Panhandle Eastern Pipe Line Company, of Kansas City, Missouri, to construct facilities for the delivery of natural gas to the National Petro-Chemicals Corporation's plants near Tuscola, Illinois.

The decision, which is subject to review by the Commission, authorizes Panhandle to deliver on an interruptible basis up to 7,000,000 cu ft of natural gas per day for use as fuel in Petro-Chemicals' extraction and chemical plants from September 16 through April 15, and up to 24,000,000 cu ft daily during the other five months of the year.

Caterpillar to Construct New Plant in Illinois

Selection of Decatur, Illinois, as the site of a new manufacturing plant has been announced by Caterpillar Tractor Company.

Plans for the new plant, which will devote its facilities to the manufacture of motor graders and industrial wheel tractors, are part of the company's post-war expansion program. Total cost of new machinery and equipment at all plants, and of land and buildings at the new plant, in the latest realignment of the company's manufacturing facilities, is estimated at about $45,000,000.

Recently named to assist Warren Kinsey, who has been announced as the manager of the new plant, are A. W. Johnson, manager of manufacturing; Ridley Orton, purchasing agent; H. O. (Pat) Nelson, manager of employee relations, and C. A. Vobroucek, chief accountant.

Johnson, employed by the Russell Grader Manufacturing Company, prior to the merger of that company with Caterpillar in 1928, has been identified with road machinery manufacture since 1926. Until being named to Kinsey's staff he had been factory manager at Peoria in charge of manufacturing.

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Pipe Line Projects

West Virginia Storage Pool Development Okayed by FPC

The Federal Power Commission has authorized Hope Natural Gas Company, of Clarksburg, West Virginia, to develop an underground natural gas storage pool in Lewis and Harrison counties, West Virginia. Estimated cost of the project is $1,236,000.

Hope will construct a total of about 19 miles of pipe line to change the status of its Kennedy gas field from a producing field to a storage field. The company will recondition 46 of the existing wells and redrill 15 abandoned wells.

Storage capacity of the pool will be approximately 20 billion cubic feet of natural gas, of which 10 billion cubic feet will be active. The company estimates that withdrawal rates will be approximately 100 million cubic feet daily with a maximum of 125 million cubic feet.

230-Mile Products Line Begun Between Indiana and Michigan

Standard Oil Company (Indiana) has started construction on all sections of a new 238-mile refined products pipe line from Whiting, Indiana, to River Rouge, Michigan.

Products will be supplied to the new 10-and-12-inch pipe line by the company's Whiting refinery. The line will connect with Standard's five other products pipe lines in seven midwestern states, which total 1731 miles in length. It will also be possible to supply the line with products from the company's Sugar Creek, Missouri, and Neodesha, Kansas, refineries. The new line will transport the company's various grades of gasoline, kerosene, furnace oils, heater oils, and diesel fuels.

El Paso to Acquire West Texas Facilities

The Federal Power Commission has affirmed a presiding examiner's decision granting applications by El Paso Natural Gas Company to acquire pipe line facilities from West Texas Gas Company, Lubbock, Texas, now used by West Texas to supply natural gas to Southern Union Gas Company, Dallas, Texas.

The transaction will eliminate West Texas as a "middle man" in the operation by which El Paso's gas moves to Southern Union. The decision also authorizes El Paso to construct a new metering station at the point of delivery to Southern Union near the Texas-New Mexico state line, and authorizes Southern Union to build additional facilities on its system.

Two huge underground storage caverns near Gibsland, Louisiana, have been completed by General Gas Corporation and are being filled with 4,000,000 gallons of liquefied petroleum gas, stored for marketing during peak winter demands. The project is the latest development in underground storage of petroleum products.

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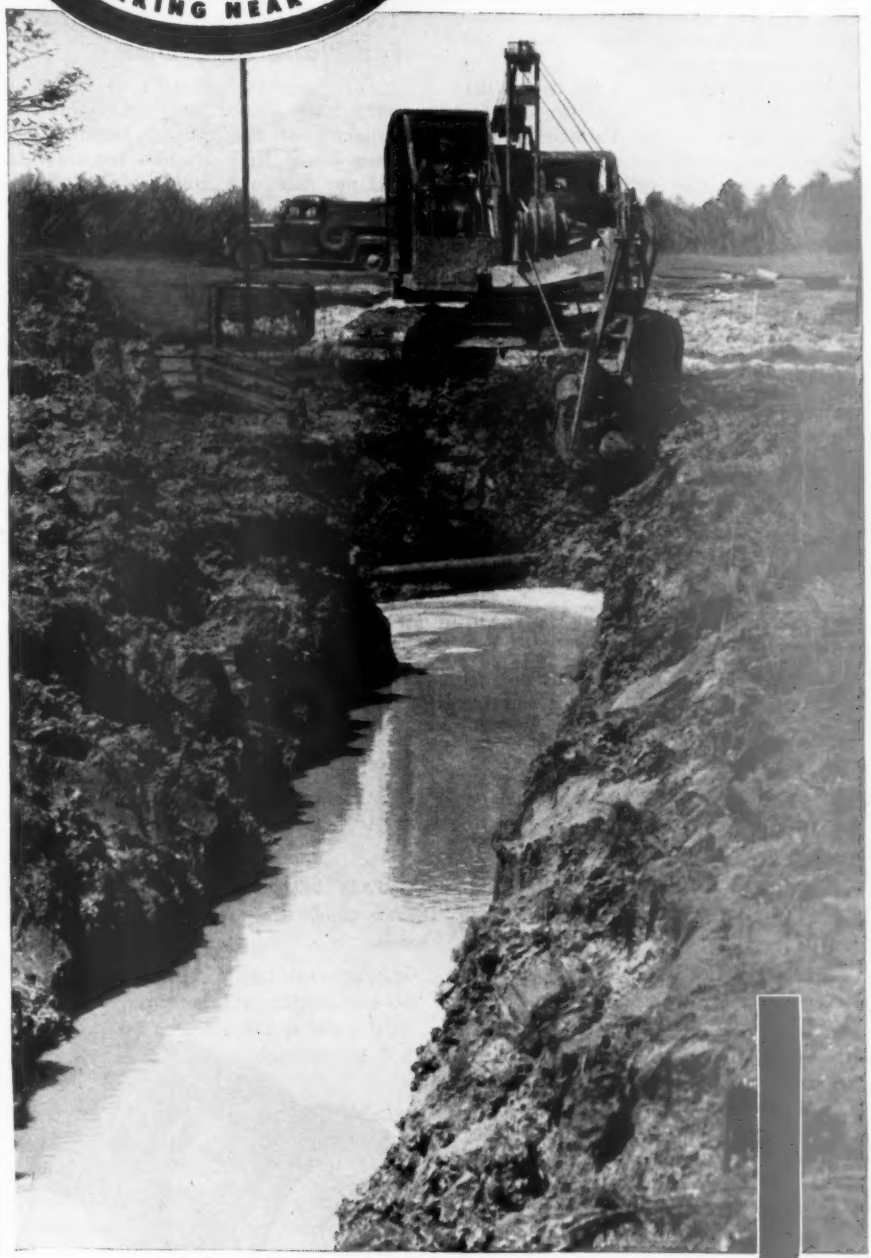

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Pipe Line Projects

Lone Star to Build New 36-Mile Wset Txeas Line

Lone Star Gas Company has completed plans for construction of a 36-mile pipe line from Stamford to Abilene which will strengthen the gas supply for towns in eight West Texas counties. Costing in excess of $838,000, the 12-in. pipe line will join the transmission system at Lone Star's compressor station near Abilene, cross Jones County and terminate at Stamford.

Maximum capacity of the line will be 30,000,000 cu ft per day with top pressure of 500 psi at the Abilene compressor station and 400 psi at Stamford. Gas entering the line will come through present delivery facilities from supplies in Scurry County, the Runnels County area, Lone Star's underground gas storage project at View, near Abilene, and points in the Abilene-Sweetwater producing area.

Construction will begin within 30 days. Construction work will be carried out by regular Lone Star crews.

Two New Stations Planned For Platte Pipe Line

Directors of the Platte Pipe Line Company have authorized expansion of the capacity of the new 1149-mile Wyoming-Wood River system from 110,000 bbl per day to 145,000 bbl per day.

Expansion of the line's capacity will come through construction of two new pumping stations at Holdrege, Nebraska, and Gower, Missouri, raising the line's total to six stations.

Other operating developments reported by the line include announcement that crude oil has started moving through the 97-mile Big Horn Basin line. The 12- and 14-in. extension runs from Byron, Wyoming, via Oregon Basin, to Chatham, and the crude moves into the larger system through Casper station.

Hearing Date Set on Cities Service Application

The FPC will hold a hearing beginning September 14 in Washington, D. C., on an application by Cities Service Gas Company, of Oklahoma City, Oklahoma, involving the construction of natural gas pipe line facilities in Ford County, Kansas.

Cities Service filed its application on June 30, 1952, requesting authority for the construction of a connection with the facilities of Natural Gas Pipeline Company of America, of Chicago, Illinois.

The application also asked authority for the temporary sales of gas to the Chicago company through these facilities. The FPC on July 14, 1952, granted temporary authorization to Cities Service for the sale and delivery of 16,500,000 cu ft of gas per day to Natural through September 30, 1952.

Plantation Products Line Extension Underway

Extension of its 14-in. products pipe line from Charlotte to Greensboro, North Carolina, is expected to be completed in autumn by Plantation Pipe Line Company. The 82-mile extension, along with related facilities, is expected to cost approximately $4,500,000. Anderson Brothers Corporation, Houston, Texas, has the construction contract for the extension.

Lone Star Gas Building 44-Mile East Texas Line

The Lone Star Gas Company of Dallas has begun construction of a 44-mile pipe line which will tap the newly developed Red Springs field twelve miles north of Tyler and strengthen the gas supply for about twenty towns in five East Texas counties. The 12-in. diameter transmission line plus gathering lines, well lines and other facilities, designed under the supervision of Thomas S. Bacon, chief engineer, will cost in excess of $1,140,000.

From the Red Springs field, the pipe line will extend northwest through Smith County, go under the Sabine River, cross Wood County and terminate in Hopkins County 5½ miles southeast of Sulphur Springs.

Initial capacity of the 44-mile transmission line will be 15,000,000 cu ft daily. It will be supplied by wells owned by the Humble Oil and Refining Company in the Red Springs field.

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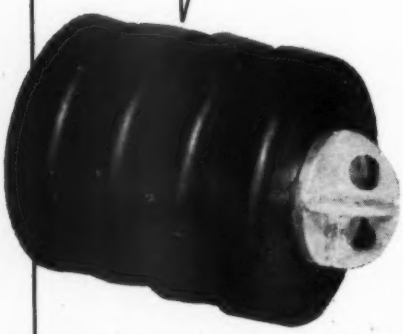

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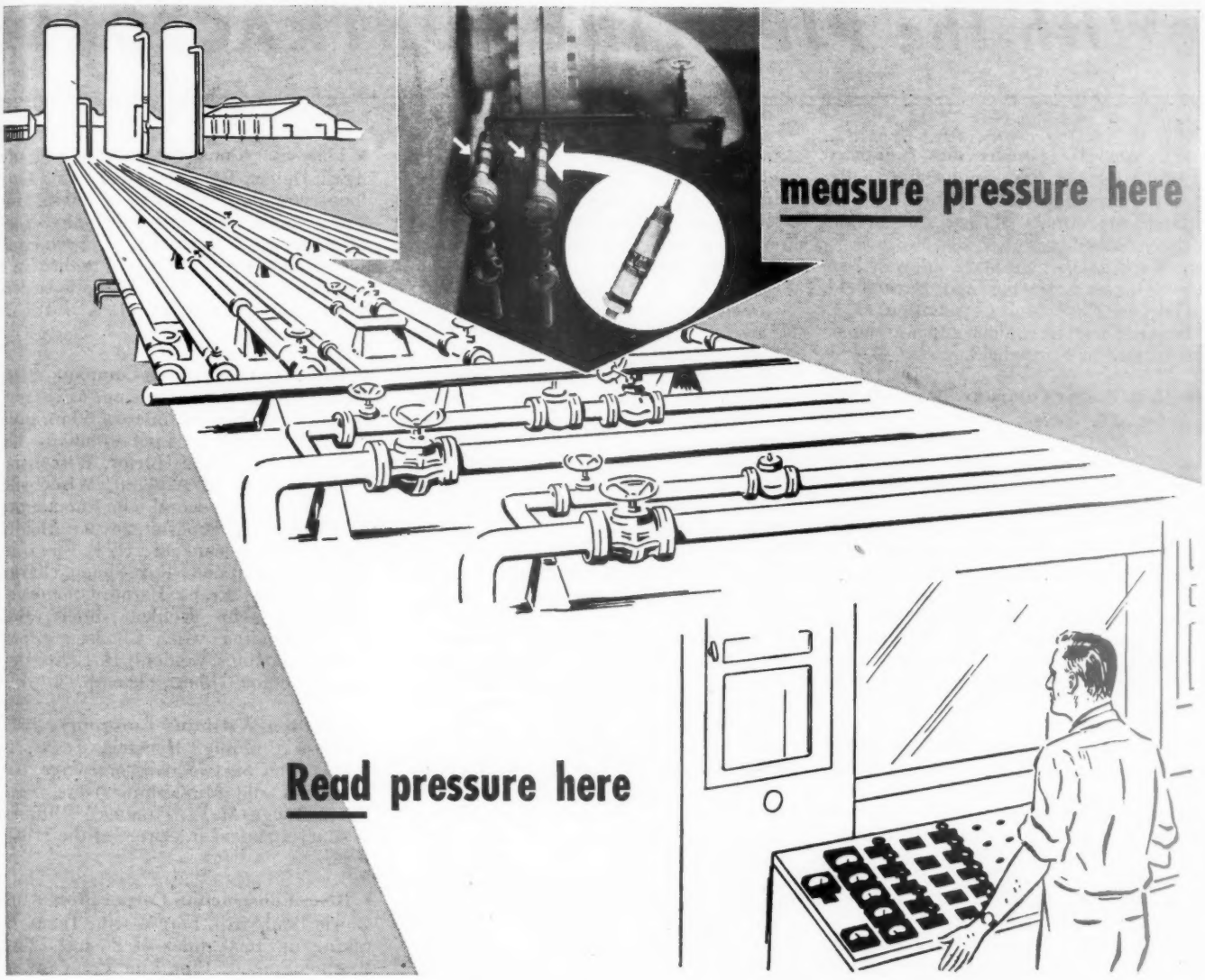

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Plantation reports that their SR-4 Pressure Measuring systems, in operation for a year at all 12 dual line pumping stations between Baton Rouge, La. and Charlotte, N.C., have required virtually no maintenance and have greatly reduced personnel required for maintenance of equipment and calibration of instruments. There are five reasons why the SR-4 system is so economical for pipe line control.

1. It is more accurate. Capacities of the cells range up to 1500 psi and the overall accuracy is 1% of full scale.

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It will pay you to investigate the *unlimited uses* for Baldwin SR-4 Devices. For example, in addition to pressure measurement on pipe lines, SR-4 Pressure Cells can depth gage storage tanks or measure ultra-high pressures, surges and explosion waves. For complete information about these uses as well as a multitude of SR-4 applications in measuring torque and load, *write* Dept. 3130, Baldwin-Lima-Hamilton Corporation, Philadelphia 42, Pennsylvania.

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With the PIPE LINE CONTRACTORS

Somerville Construction Company, Ada, Michigan, has completed 102 miles of 12-in. products line for Standard Oil (Indiana), from Whiting, Indiana, to Colon, Michigan.

Work has begun on 22 miles of 8-in. line between Dayton and Springfield, Ohio, for the Inland Corporation. O. P. Hiner is superintendent and warehouse is located at Springfield.

H. B. Zachry Company, Box 2570, San Antonio 6, Texas, is working on 154 miles of 16-in. pipe between Ringgold and Corsicana, Texas, for Magnolia Pipe Line Company. D. B. Shrum is superintendent and Ray Shields, office manager.

Western Pipe Line Constructors, Box 798, Austin, Texas, is working on 164 miles of 30-in. line for El Paso Natural Gas Company between Kingman and Flagstaff, Arizona. Benny Williams is superintendent and P. O. Rutledge office manager at the Williams, Arizona, field office.

Tellepsen Construction Company, Houston, Texas, is constructing an underwater gas gathering system in Lake Maracaibo, Venezuela, for Creole Petroleum Company. The system will embrace about 14 miles of 24-, 26-, and 30-in. pipe.

Pentzien, Inc., Omaha, Nebraska, is constructing a Missouri River crossing near Bismark, North Dakota, for Standard Oil Company of Indiana's new line. James Zeman is superintendent and the field office is at Bismark.

Company also has contract for Missouri and Little Missouri River crossings in North Dakota for Service Pipe Line Company. Forrest Andrews is superintendent.

Williams-Austin Company, Grant Building, Pittsburgh, Pennsylvania, has started work on approximately 11 miles of line in the Caledonia, New York, area for New York State Natural Gas Corporation. Ralph Gaddy is in charge.

Preliminary work is underway on 11.5 miles of 12-in. pipe for Niagara Mohawk Power Corporation between Amsterdam and Gloversville, New York, with Howard Bauer supervising. Ed Peters is general superintendent and L. A. Franks office manager. Central warehouse is at Cortland, New York.

H. C. Price Co., Pipeline Division, P. O. Box 1111, Bartlesville, Oklahoma, has the general contract covering construction of approximately 355 miles of 30-in. high pressure natural gas pipe line for Gulf Interstate Gas Company starting at a point near Kinkade, Tennessee, and extending northeasterly to a point near Kenova, West Virginia.

A general contract covers construction of 200.4 miles of 24-in. loop and new lines for Southern Natural Gas in Mississippi, Alabama, and Georgia.

Spreads in operation include spread one, Stanford, Kentucky, G. A. Reutzel, superintendent; spread two, Irvine, Kentucky, R. L. Ezell, superintendent; spread three, Bessemer, Alabama, C. E. Shivel, superintendent; spread four, Kosciusko, Mississippi, C. R. Ice, superintendent, and spread five, Columbia, Kentucky, W. H. Olrich, superintendent.

Lyles and Young Company, P. O. Box 495, Avenal, California, is working on 136 miles of 8-in. line for Salt Lake Pipe Line Company, from Pasco to Spokane, Washington. Ronny Cook is superintendent, C. V. Miller, project manager, and C. E. Smith office manager.

Engineering-Construction Company, 402 North Cheyenne, Tulsa 6, Oklahoma, is working on 94 miles of 16-in. line for East Tennessee Natural Gas Company between Knoxville and Kingsport, Tennessee. Also being laid on the same job are 56 miles of 4- through 12-in. line in laterals from the main line. Bob Blackmon is spreadman and Emerson H. Clark, office manager, at the Morristown, Tennessee, office.

In the vicinity of Columbia, Tennessee, the company is working on 15 miles of 6-in. line. Curt Vaughan is spreadman and V. L. Bethel, office manager.

Near Pryor, Oklahoma, the company is taking up, reconditioning and relaying 12 miles of 10-in. line. Earle Hackleman is spreadman; H. B. Hoge, office manager, and Morgan Blair, in charge of materials.

Near Richmond, Missouri, a crew supervised by Bill Bolt is taking up 12 miles of 16-in. line for Sinclair Pipe Line Company. B. K. Alley is office manager.

Jobs contracted for but not started include construction of approximately 65 miles of 4- through 20-in. line near Elkhart, Kansas, for Colorado Interstate Gas Company and work for the city of Dallas, Georgia, on transmission and distribution lines.

Modern Welding Company, 1500 East 12th Street, Owensboro, Kentucky, is working on approximately 54 miles of 1- through 6-in. distribution lines in Martin, Tennessee; Oran, Missouri, and Fulton, Kentucky.

Shamrock Construction Company, 307 Mutual Building, Lansing, Michigan, has started on 22 miles of 18-in. line for Ohio Fuel Gas Company between Centerville and Selma, Ohio. Frank Park is superintendent and Hank Van Drie office manager. Same crew has 10½ miles of 8-in. line for Sohio Company near Cincinatti, Ohio.

Lone Star Constructors, 10301 Shady Trail, Dallas, Texas, is constructing four loops, totaling 70 miles of 30-in. for Northern Natural Gas Company. One of the loops, in Nebraska, has been completed and spread has moved to the three in Kansas. H. A. "Red" Wylie is superintendent in charge and J. K. Little is office manager.

Mahoney Contracting Company, 2300 North Grand River, Lansing, Michigan, is progressing on 91 miles of 30-in. pipe for Lakehead Pipe Line Company between Superior, and Hurley, Wisconsin. Field office is in Ashland, Wisconsin. Henry Mogg is general superintendent; Mike Finnerty, superintendent; Al McConnell, office manager; H. F. Emerson charge of front end; Ray Abney, charge of back end; Frank Barnard, material manager; John Kohler, ditch; Bill Morry, bending; Glen Goodson, pipe; George Hastings, welders; H. L. Sparks, dope, and Joe Gilbert, cleanup.

Panama-Williams Company, 1417 Melrose Building, Houston, Texas, is progressing on two river crossings, Atchafalaya and Mississippi rivers, near Baton Rouge. M. E. "Panama" Williams is superintendent in charge of the crossings.

River Construction Corporation, 6100 Bowie Boulevard, Fort Worth, Texas, is taking up 1600 miles of 8- and 12-in. line for Sinclair Pipe Line Company in Kansas, Missouri, Illinois, and Indiana.

Work on 107 miles of 22-in. line from Bunkie to Shreveport, Louisiana, has started. Jim Reed is superintendent and Pat Rogan office manager. On one spread, field office is at Melville, Louisiana. T. M. Tatom is superintendent and Lee Price office manager at the other spread, office is at Natchitoches, Louisiana.

Mid-States Construction Company, Mount Vernon, Illinois, is laying approximately 45 miles of 10-in. pipe for Phillips Pipe Line Company near Harrisonville, Missouri. Superintendent is Ed Veach and Bill Thompson is office manager.

Mid-States also contract for 25 miles of 10-in. line between Warrensburg and Clinton, Missouri, for Missouri Public Service Company. Job will begin on completion of Phillips project.

Missouri Dredging Company, St. Louis 6, Missouri, has contract for crossings of the Kentucky, Cumberland and Tennessee rivers for Gulf Interstate Gas Company's 30-in. line. Construction has started on the Tennessee River crossing and is expected to be completed by October 1. Work on the Cumberland job will start in September and the Kentucky job will begin in October.

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Pipe Line Contractors

G. G. Griffis Construction Company, 4450 Easet Admiral Place, Tulsa, Oklahoma, is working on three loops in Iowa for Northern Natural Gas Company. G. G. Griffis is general superintendent, Hook Miller spreadman, and R. H. Holmes, office manager at the Cherokee, Iowa, field office. The three loops are a 27-mile, 24-in. line, a 40-mile, 30-in. line and 32-mile, 30-in. loop.

Mary Construction Company, Cape Girardeau, Missouri, is working on 80 miles of 8-in. products line for the Indiana Farm Bureau Cooperative Association. The pipe is being laid between Switz City to Peru, Indiana. Garland Mims is superintendent and Lewis Wiist office manager.

Engineers Limited Pipeline Company, 225 Bush Street, San Francisco, California, is working on 25 miles of 18-in. line in Wyoming for Mountain Fuel Supply Company. Also underway is construction of 40 miles of 6-in. products line for Salt Lake Pipe Line Company between Adams, Oregon, and Pasco, Washington. Superintendent is C. P. Hamilton and Virgil Dalby is office manager.

Brown and Root, Inc., 4100 Clinton Drive, Houston, Texas, is working on 194 miles of 6, 8, 12, and 20-in. pipe line for Southern Natural Gas Company in the coastal area of Louisiana. The spread doing the construction work from Lake Sand east to the Mississippi River has its field headquarters at Franklin, where E. R. Jackson is superintendent. From the Mississippi River east for a distance of approximately 144 miles the spread is in charge of Jim Kincy, with field headquarters at New Orleans.

A. C. Holder Construction Company, 2615 East Admiral Place, Tulsa, Oklahoma, is working on 90 miles of 6- and 12-in. crude line take-up and reconditioning for a Humble-Chicago Pipe Line project between Buckner, Missouri, and Iola, Kansas. A. C. Holder is superintendent and J. D. Langley, office manager.

Lone Star Gas Company, Dallas, is working on a 44-mile, 12-in. line in Northeast Texas between Red Springs Field and Sulphur Springs in Hopkins County. Directing construction is Luther Tolbert, Lone Star pipe line superintendent. Earl Miller is construction foreman.

R. B. Potashnick, Cape Girardeau, Missouri, is making progress on 101 miles of 10-in. pipe line for Standard Oil Company of Indiana. Job is between Colon and Romulus, Michigan. A. G. Hobson is superintendent and V. E. Connor office manager.

H. L. Gentry Company, Jackson, Michigan, has contract for construction of a 16-in. line for Ohio Fuel Gas Company of Columbus, Ohio. The line is a replacement for two existing 10-in. lines.

Latex Construction Company of Georgia, P. O. Box 56, North Side Station, Atlanta, Georgia, is working on 294 miles of 14, 16, and 18-in. pipe line for Southern Natural Gas Company in Alabama and Georgia. Field headquarters are in Augusta, Georgia, with J. M. Phipps superintendent, Jim Davenport, spreadman, and A. C. Andrews office manager.

Ohio Pipe Line Construction Company, Granville, Ohio, is working on 17 miles of 16-in. line near Lima, Ohio, for Ohio Fuel Gas Company. H. J. McAdams is superintendent and Evelyn Helbert office manager.

Hoss Heavy Haulers, Laurel, Mississippi, is stringing 107 miles of 22-in. line for River Construction Corporation on an Interstate Oil Pipe Line Company project between Shreveport and Bunkie, Louisiana.

C. W. Fowler, Cotton Valley, Louisiana, is working on 65 miles of 12-in. line and 10 miles of 8-in. line between Bobstown and Seadrift, Texas, for Seadrift Pipe Line Company. R. B. Kemper is superintendent and W. G. Barnett office manager at the Refugio, Texas, field office.

Merritt-Chapman and Scott, 260 Madison Avenue, New York 16, New York, has contract for a pipe line system in India to link two refineries under construction at Bombay, India.

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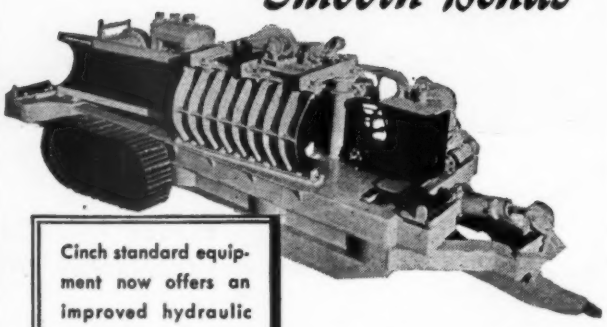

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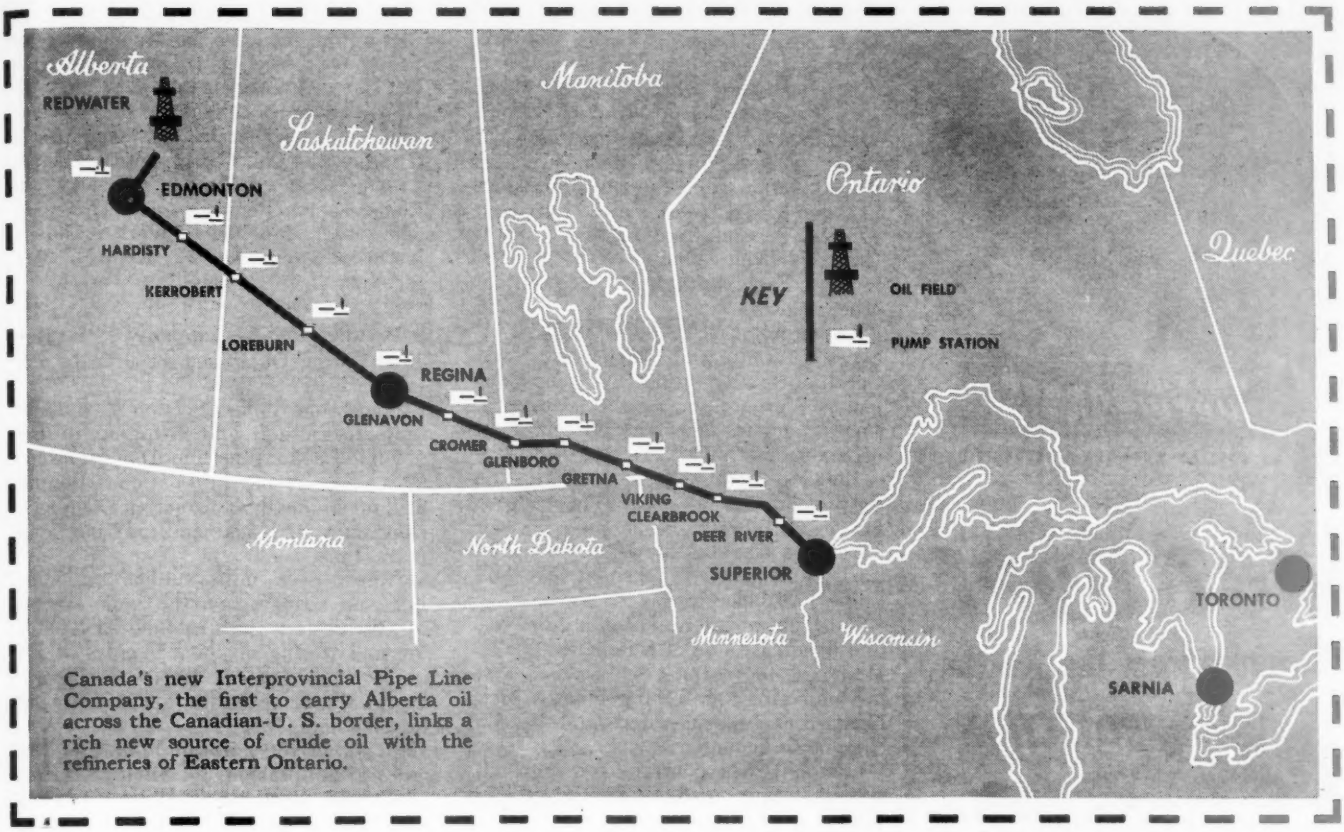


Canada's new Interprovincial Pipe Line Company, the first to carry Alberta oil across the Canadian-U. S. border, links a rich new source of crude oil with the refineries of Eastern Ontario.

Alco Diesel Engines Pump Alberta Oil 1137 miles to U.S. Port on Great Lakes

Canada's new 1137-mile Interprovincial Pipe Line and its American Subsidiary, Lakehead Pipe Line Company, Inc., offer an outstanding example of international teamwork—and open a new era in the history of Canadian petroleum.

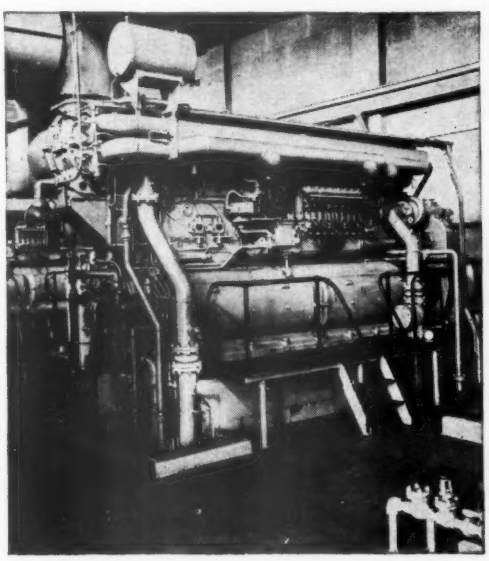
Served by Alco Diesel Engines, this first major Canadian pipeline (approximate annual capacity: 58.5 million barrels out of Edmonton) carries crude oil from the rich fields of central Alberta to the strategically located Great Lakes port of Superior, Wisconsin, from where it is transported to the refineries of Eastern Ontario.

Nine of the line's twelve pumping stations are located in Canada, three in the U. S. (see map). Each is powered by either two, three or four Alco Diesel Engines. Units for the Canadian stations were built under Alco license by the Dominion Engineering Works of Montreal; U. S. units were built in Alco's diesel plant at Auburn, N. Y.

Some of these 12½ in. x 13 in. engines have six cylinders and others, eight. Some are straight diesel and others are dual fuel. All of the engines are suitable for burning available crude oil.

The new Interprovincial Pipe Line is just one more major installation where the compactness, efficiency and flexibility of Alco Diesel Engines are helping to meet the free world's growing demand for petroleum products.

Your nearest Alco sales representative will be happy to give you detailed information on Alco Diesel Engines. Contact him at New York, Beaumont, Chicago, Cleveland, Houston, Kansas City, San Francisco, Schenectady or St. Louis.



Eight cylinder, 12½ in. x 13 in. Alco dual-fuel Diesel Engine, manufactured in Canada by Dominion Engineering Works, Montreal, shown in engine room of the Interprovincial's Edmonton, Alberta, pumping station.

ALCO DIESELS

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HOT DOPE

Straight from the Kettle

on PIPE PROTECTION

★

By Boyd Mayes

A banker friend dropped by recently to pass the time of day and ended up passing along some of what he called fatherly advice.

"You ought to tear yourself away from this plant for a change, and relax. Take a long trip, maybe Europe, maybe Asia. You've been too many years all work, no play. You should lay off and take a *real* rest . . . even a trip around the world."

Maybe the guy had something. Everybody needs a rest. Personally, though, we were never much on travel. Up around Huntsville, Texas, where we came from, about the farthest you ever got away from home was the distance you followed an old hound dog into the piney woods looking for a 'coon. Besides that we figure, with the way things are going right now, the folks in Europe and Asia need a rest a durn sight more'n we do. So, we figure we'll just stay on here with the job of Cleaning, Coating, Wrapping and Weighting pipe. If it gets too tiresome we can always stroll back up to Walker County and turn the old hound loose again.

But, that banker at least got us thinking. It's 25 thousand miles (as the crow flies) around the world. That makes 132 million feet. Our records show that in 26 years of staying home and working we've conditioned almost exactly 350 million feet of pipe, including all sizes. If all this work were laid end to end and we started following it we'd go around the world nearly three times. May sound like silly thinking . . . but what a *trip* that would be!

MAYES BROS.

1150 McCarty HOUSTON, TEXAS ORchard 7566

Pipe Line Contractors

▸ **Anderson Brothers Corporation,** P. O. Box 2591, Houston, Texas, has three spreads in operation on 180 miles of 30-in. line being laid between the Michigan-Wisconsin state line to Cooks, Michigan, for Lakehead Pipe Line Company. K. B. Killingsworth is in charge of the section from the state line starting point to Crystal Falls, Michigan. Another section from Crystal Falls to Cooks is being supervised by Aldress Kilgore. Earl Saulsmann is directing the other spread.

Construction of 82 miles of 14-in. between Charlotte and Greensboro, North Carolina for Plantation Pipe Line Company is progressing. R. E. Magee is superintendent and Dick Bond, office manager.

Between Scottsville, Kentucky, and Springfield, Tennessee, work is progressing on 48 miles of 30-in. pipe line for Tennessee Gas Transmission Company. Earl Saulsman is superintendent and Eddie Ball office manager.

Work has begun on 117 miles of 16-in. line from east side of Kalamazoo River, Michigan, to Wayne County, Michigan, for Wolverine Pipe Line Company. Dick Leonard is superintendent and W. W. Kirk office manager.

Company has contract for approximately 70 miles of 3-, 4-, 12-, and 24-in. natural gas line for Gulf Interstate Gas Company in Louisiana.

▸ **Anderson International Constructors, Inc.,** Rawleigh Building, Edmonton, Alberta, Canada, is completing work for Trans Mountain Pipe Line Company.

Work has also begun on 135 miles of 24-in. for Interprovincial Pipe Line Company, which will be laid in four loops in Saskatchewan and Manitoba. One spread is in operation in Manitoba with Dick Jernigan in charge.

▸ **Associated Pipe Line Contractors, Inc.,** Houston, Texas, is working on 200 miles of 10-in. line from Bismark to Fargo, North Dakota, for Standard Oil Company. Jim Ed Andrews is superintendent and Buck Johnson office manager at the Bismark field office.

Company is also working on 40 miles of 14-in. pipe line for Texas Company in Louisiana, from Paradise to Golden Meadow. Willie Briley is superintendent and R. N. Cain office manager.

▸ **Bechtel Corporation,** 220 Bush Street, San Francisco, California, is acting as agent for the Lakehead Pipe Line Company, in constructing the $76,000,000 635-mile, 30-in. pipe line between Superior, Wisconsin, and the international boundary south of Port Huron, Michigan, and Sarnia, Ontario. It will act as agent in the management and construction of the project. An office has been established at 124 South Washington Avenue, Saginaw, Michigan. Van W. Rosendahl, senior vice president of Bechtel, is in charge. Assisting him are Clark Rankin, project engineer; J. V. Chambers, project administrative manager; J. Don Creveling, lands manager; E. F. Quiett, construction manager, and T. Ray Johnson, public relations officer.

Bechtel construction crews are completing the section from Mackinaw City to Red Oak, Michigan. The field office is at Gaylord, Michigan, with M. A. Roberts superintendent.

Another project by this company is 63 miles of 24-in. for the Tennessee Gas Transmission Company, from Kane to Coudersport, Pennsylvania. The field office is at Kane. J. L. Work is superintendent and K. F. Kenna office manager.

▸ **Parkhill Truck Company,** P. O. Box 1856, Tulsa, Oklahoma, reports the following work:

Ninety-one miles, Section I, unloading, stockpiling, and stringing of the 630-mile, 30-in. pipe line from Superior, Wisconsin, to the International Boundary, for Mahoney Contracting Company, contractor for Mackinac Pipe Line Company, Inc.

Ninety-seven miles, unloading, storing, and stringing on the same system for Midwestern Constructors. Also hauling and storing of about 9 miles of 20-in. river pipe from St. Ignace, Michigan, to the Mackinac Straits for Midwestern Constructors, Inc.

Stringing 280 miles of 14-in. and 320 miles of 8-in. takeup for Shell Oil Company from Wood River, Illinois, to East Chicago, Indiana. The prime contractor is R. B. Potashnick Company.

Stringing 180 miles of 8-in. pipe for the Indiana Farm Bureau between Mount Vernon, Illinois, and Indianapolis, Indiana. The prime contractor is R. B. Potashnick.

Stringing 16-in. line pipe on the Wolverine line from East Chicago, Indiana, to a point near Marshall, Michgian, for Midwestern Constructors, Inc.

Stringing from El Dorado, Kansas, to Arkansas City, Kansas, 74 miles of 8⅝-in. pipe, and 130 miles of 10¾-in. pipe from Potwin to McPherson, Kansas, and Fairmount, Nebraska, for Ray L. Smith and Son, Inc.

Hauling 30-in. pipe for Gulf Interstate Gas Company from Houston and Orange, Texas, to storage points in eastern Louisiana and Mississippi.

Stringing 40 miles of 6-in. pipe from a point near Pasco, Washington, to a point near Adams, Oregon, for Engineers Limited Pipeline Company on Salt Lake Pipe Line Company job.

▸ **Pipe Line Construction and Drilling Company,** Indiana, Pennsylvania, is working on 50 miles of 14-in. line for Buckeye Pipe Line Company between Allentown and Wilkes-Barre, Pennsylvania. Merrel Foudray is superintendent in charge and Fred Droddy office manager at Berlinsville, Pennsylvania.

▸ **Conyes Construction Corporation,** 2884 San Pablo Avenue, San Pablo, California, is working on 180 miles of 30-in. line for Lakehead Pipe Line Company from Red Oak to Marysville, Michigan. Two spreads are in operation, with J. L. Walker, Morris A. Norwood, and Chet Kinkaid, superintendents of the projects.

Pipe Line Contractors

Comstock Midwestern, Ltd., 206 Laird Drive N., Leaside, Ontario, Canada, is completing work on the Trans Mountain Oil Pipe Line Company system. The section is between Edmonton and Vancouver. Office is at Vancouver, British Columbia, with C. I. Rathgeb, Jr., project engineer, and K. A. Owens assistant.

O. R. Burden Construction Corporation, P. O. Box 5216, Tulsa, Oklahoma, is constructing 153 miles of 12-in. and 16-in. crude oil line for Service Pipe Line Company between Tioga and Mandan, North Dakota. Two river crossings also will be installed. The field office is at Tioga. A. B. Haynes is superintendent and J. R. Perkins office manager.

Company also has approximately 51 miles of take-up for Sinclair Pipe Line Company on an 18-in. line in Missouri and Kansas.

Contracting and Material Company, 1235 Dodge Avenue, Evanston, Illinois, is constructing 20 miles of 30- and 36-in. line for Chicago District Pipe Line Company. A. J. Fry is superintendent and J. H. Myers office manager.

Midwestern Constructors, Inc., 105 North Boulder, Tulsa 3, Oklahoma, is working on 97 miles of 30-in. pipe line between Cooks and St. Ignace, Michigan, for Lakehead Pipe Line Company. M. T. Wilhite is superintendent, John Work, spreadman, and A. T. Tolbert, office manager, at St. Ignace.

Construction is in the finishing stages on the 2750-ft of 30-in. underwater crossing of the St. Clair River at International boundary between Sarnia and South Port Huron for Lakehead Pipe Line Company.

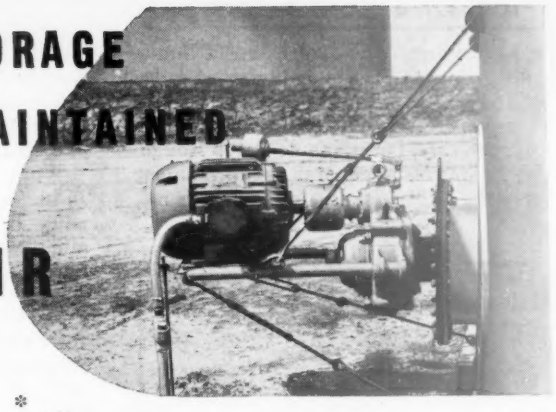
Work is nearly complete on a sub-contract for land work from Merritt-Chapman and Scott Corporation for two 20,000-ft 20-in. lines across Mackinac Straits, between Port LaBarbe and McGulpin Point, Michigan, for Lakehead.

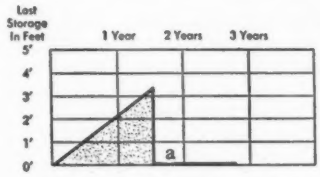
Work is nearly complete for Texas Illinois Pipe Line Company on station additions at Hoffman, Illinois, and construction of a compressor station at Hammond, Illinois. J. M. Graham is superintendent; W. D. Kaufman, office manager, and Doyle Cooper, engineer, at the Hoffman site. Ray M. Johnson is superintendent; W. C. Ryan, office manager, and Lonnie Dorman, engineer at the Hammond job.

Work on 153 miles of 16-in. line east side of Kalamazoo River in Michigan to Kennedy pump station at East Chicago, Indiana, is progressing. M. T. Wilhite is superintendent, John Petty, spreadman, and A. T. Tolbert, office manager. Office is at Battle Creek, Michigan.

Oklahoma Pipe Line Constructors, 6612 Hines Boulevard, Dallas, Texas, is laying approximately 150 miles of 30-in. line for El Paso Natural Gas Company from Denver City, Texas, to near Roswell, New Mexico. A field office has been opened at Lovington, with Louis Visentine as superintendent and R. F. Mueller office manager.

MAXIMUM STORAGE FACILITIES MAINTAINED with a SHORTSTIR as proven by actual Pipe Line company records.*





(a) tank cleaned and SHORTSTIR installed.

* These records show that sediment had accumulated, in some cases, at a rate of over 2 ft. per year. Tanks were cleaned and SHORTSTIR Mixers installed. Thiefing after one year revealed less than 1" sediment.

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Pipe Line Contractors

▸ **L. E. Farley, Inc.,** 2609 Sunset Boulevard, Houston, Texas, is laying 64 miles of 16-in. pipe for Interstate Natural Gas Company, from Bateman Lake near Morgan City, Louisiana, to Baton Rouge. W. L. Barton is general superintendent over the two spreads, one of which has its field headquarters at Plaquemine and the other at Morgan City. Fred Hudson is office manager at Plaquemine. At Morgan City Jesse Finley is spreadman and Paul Upton office manager.

Work also is underway on 55 miles of 16-in. for Interstate Oil Pipe Line Company between Raceland and Plaquemine to a point near Baton Rouge.

▸ **Fulghum Contracting Corporation,** Box 1181, Harrisburg, Pennsylvania, is finishing up 51.5 miles of 14-in. pipe line between Dupont, Pennsylvania, and the Pennsylvania-New York state line for Buckeye Pipe Line Company. A. L. McMillon is superintendent at the Montrose, Pennsylvania, field office.

▸ **R. H. Fulton and Company,** P. O. Box 1526, Lubbock, Texas, is constructing 63 miles of 18-in. line for El Paso Natural Gas Company between Clear Creek and Provo, Utah. Superintendent in charge is Jerry Nash with Jack Frazer the office manager.

Fulton is working on 260 miles of 16, 20, 24, 26, and 30-in. line for the Permian Basin Pipe Line Company in loops from Hobbs, New Mexico, to Denver City, Texas, to Midland, Texas, to Rankin, Texas, and back to Hobbs. Two spreads are working on the job. M. L. Boyd is superintendent at the Midland, Texas, field office, and Oscar Phillips is superintendent at the Hobbs, New Mexico, field office.

Underway also are 90 miles of 30-in. loop line for Permian Basin Pipe Line Company between Perryton, Texas, and Noals, Oklahoma. Vance Albers is superintendent and Claude Helweg, office manager.

Fulton also has 50 miles of 20-in. pipe between Hugo and Eads, Colorado, for Colorado Interstate Gas Company. Jim Gill is superintendent and Frank Tidwell office manager.

▸ **Houston Contracting Company, Ltd.,** 2707 Ferndale Place, Houston, Texas, has the following construction work:

Approximately 440 miles of 14-, 16-, 18-, 20-, and 24-in. natural gas lines for Southern Natural Gas Company in Georgia, Alabama, Mississippi, and Louisiana. Spreads now working as follows:

Approximately 82 miles of 16-in. and 35 miles of 14-in. from Bass Junction, Georgia, to a point south of Wrens, Georgia. H. L. Leake, superintendent; S. B. Harrison, assistant superintendent; George A. Warner, field office manager; present headquarters, Milledgeville, Georgia. About 50 miles completed.

Approximately 120 miles of 14- and 16-in. in Georgia has been sub-contracted to Latex Construction of Georgia. Present headquarters Sylvania, Georgia. About 55 miles finished.

Approximately 20 miles of 18-in. reconditioning for Texas Gas Transmission Corporation near Greenville, Mississippi. H. J. Muckley, superintendent; A. E. Stremmel, field office manager; headquarters, Greenville, Mississippi.

Approximately 500 miles of 30-in. natural gas line for Gulf Interstate Gas Company from Rayne, Louisiana, to Kinkade, Tennessee. Three spreads on this work as follows:

From Mississippi River going north, E. C. Norris, superintendent; R. E. Thornton, assistant superintendent; R. J. Axsom, field office manager; present headquarters, Hollandale, Mississippi. Approximately 20 miles completed.

From Ouachita River going south, F. A. Silar, superintendent; L. F. Redfearn, field office manager; headquarters, Jena, Louisiana.

From Ouachita River going north, W. H. Hayes, superintendent; M. L. Thompson, assistant superintendent; J. B. Stoddard, field office manager; headquarters, Winnsboro, Louisiana. Expect to start laying pipe about September 15th.

▸ **McDonough Construction Company of Georgia,** Atlanta, Georgia, is working on 50 miles of 6- and 8-in. line for the Cullman-Jefferson Counties Gas District. D. B. Samford is superintendent and J. A. Preston, office manager.

▸ **Ray L. Smith and Son, Inc.,** Hazlett Building, P. O. Box 391, El Dorado, Kansas, is constructing 234 miles of 8- and 10-in. products line between Wichita, Kansas, and Fairmont, Nebraska, for Kaneb Pipeline Company. Three spreads are in operation. R. M. Jones is superintendent and Tom Davis office manager for spread one; Carl S. Colvin is superintendent of spread two, and Dewey Whitworth is superintendent and D. L. Marley office manager on spread three.

▸ **Holdran Construction Company,** Mount Vernon, Illinois, is working on an undetermined amount of cross-country transmission lines and city distribution lines near Rock Island Illinois, for Iowa Illinois Gas and Electric Company. H. W. Randall is superintendent and N. W. McCoy office manager.

▸ **Williams Brothers Company,** National Bank of Tulsa Building, Tulsa, Oklahoma, is working on a gathering system in the Williston, North Dakota, area for Signal Oil and Gas Company, which will connect with the latter's gasoline plant. Approximately 150 miles of pipe, 4 in. through 30-in. will be laid. Eddie Hubach is in charge of work at the Tioga, North Dakota, field office.

Between Sarnia and Toronto, Ontario, Canada, work is underway on approximately 200 miles of 8-in. line for Sun Oil Company. Jimmy Childress is superintendent. Field office is at Strathroy, Ontario, Canada.

▸ **El Paso Natural Gas Company,** El Paso, Texas, has crews working on 300 miles of 4- to 16-in. gathering system lines near Bloomfield, New Mexico, at the Blanco field. Superintendent is Joe Self and B. R. Jones, office manager.

El Paso crews are also starting on 200 miles of 30-in. line from Winslow, Arizona, to Gallup, New Mexico. J. E. Lowry is job superintendent and J. S. Smith, office manager.

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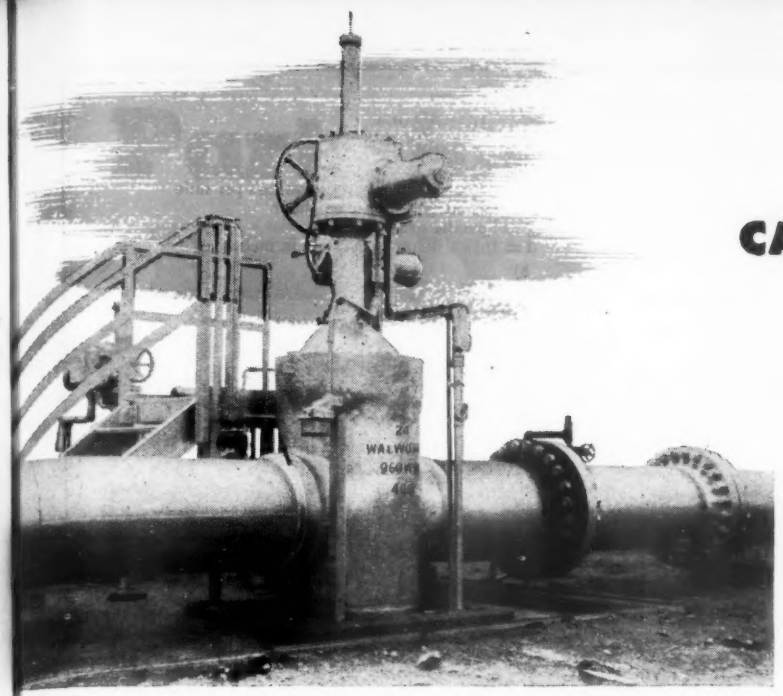
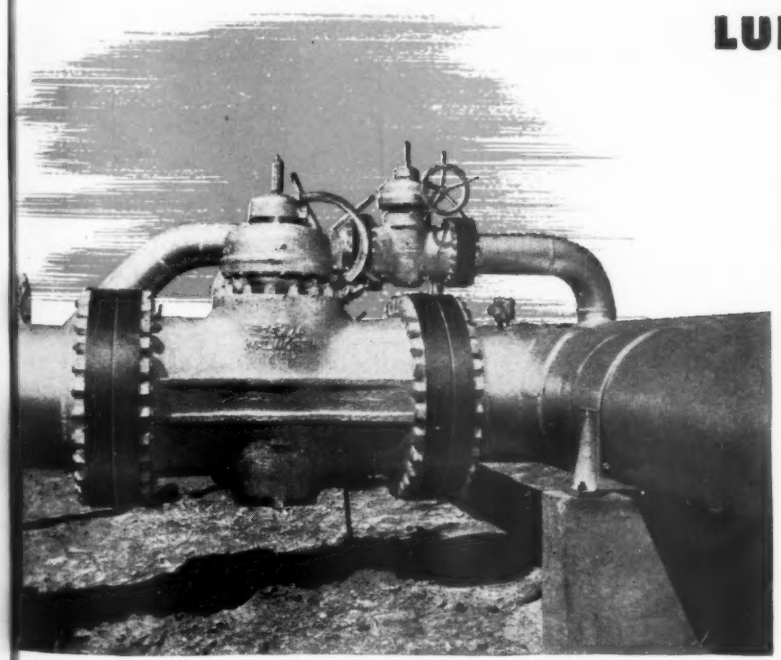


CAST STEEL GATE VALVES

A 24-inch Walworth Type 49 Series 400, 960 WOG, Cast Steel Gate Valve with welding ends and motor operating device, on a pipeline handling crude petroleum.

Walworth Type 49 Valves are especially designed for service on pipelines handling gas, refined products, or crude oil. Through-port construction allows free passage of pigs and scrapers. These valves do not require any internal lubrication and may be installed without regard to direction of flow.

WALWORTH makes both for pipeline service



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Walworth Lubricated Plug Valves afford quick, easy operation . . . a quarter turn gives full, direct port opening. The lapped surfaces of the plug and body, plus the seal afforded by the lubricant, assure a tight, leakproof valve.

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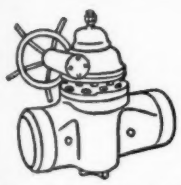

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Sizes 2 to 30 inches, inclusive. Series 400 and 600 for working pressures up to 1440 psi.

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FORMULA:—

$$P^{0.54} = \frac{162.04\ Q^{0.54}}{cd^{2.63}}$$

Where
P = Pounds per sq. in. friction loss per mile
Q = Discharge in bbls. per hour
g = Specific gravity
d = Inside diameter of pipe in inches

EXAMPLE

Given: To transport 20 bbls./hr. of 1.13 sp. gr. salt water through 3" I.D. pipe which has a roughness coefficient "C" of 125

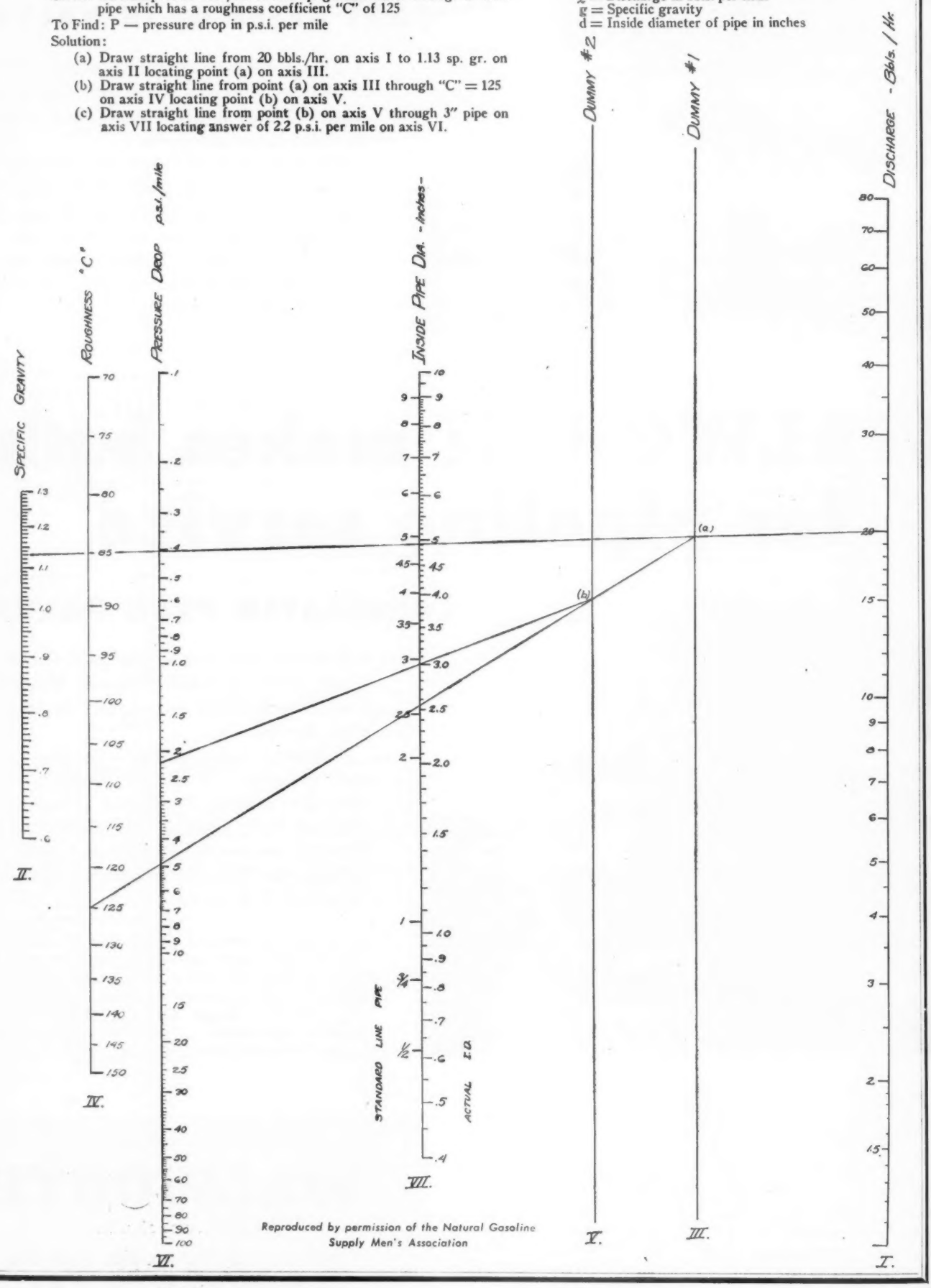
To Find: P — pressure drop in p.s.i. per mile

Solution:

(a) Draw straight line from 20 bbls./hr. on axis I to 1.13 sp. gr. on axis II locating point (a) on axis III.

(b) Draw straight line from point (a) on axis III through "C" = 125 on axis IV locating point (b) on axis V.

(c) Draw straight line from point (b) on axis V through 3" pipe on axis VII locating answer of 2.2 p.s.i. per mile on axis VI.



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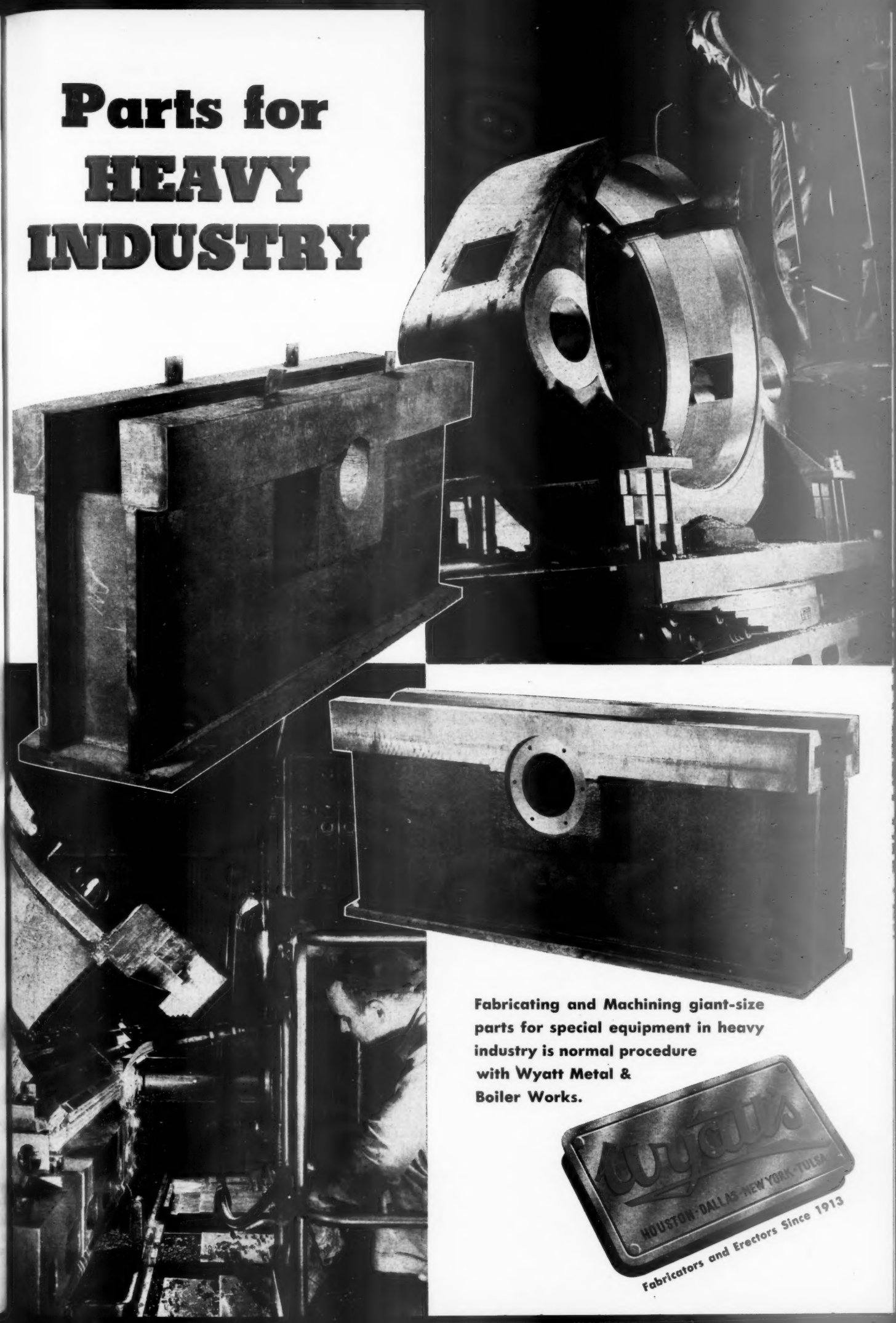

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THERMAL METHOD OF LOCATING CASING LEAKS OR CIRCULATION LOSSES

FIG. 1

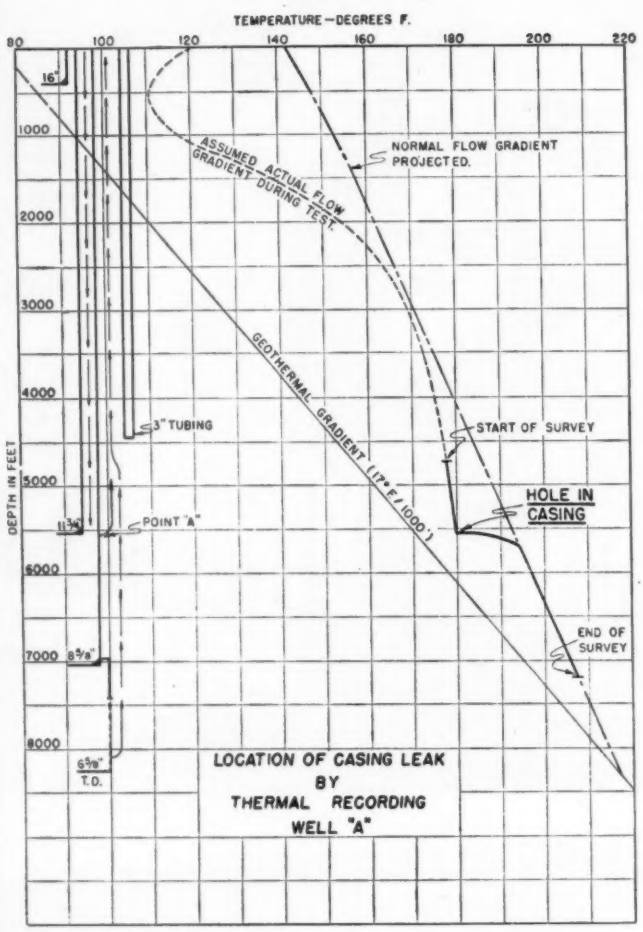
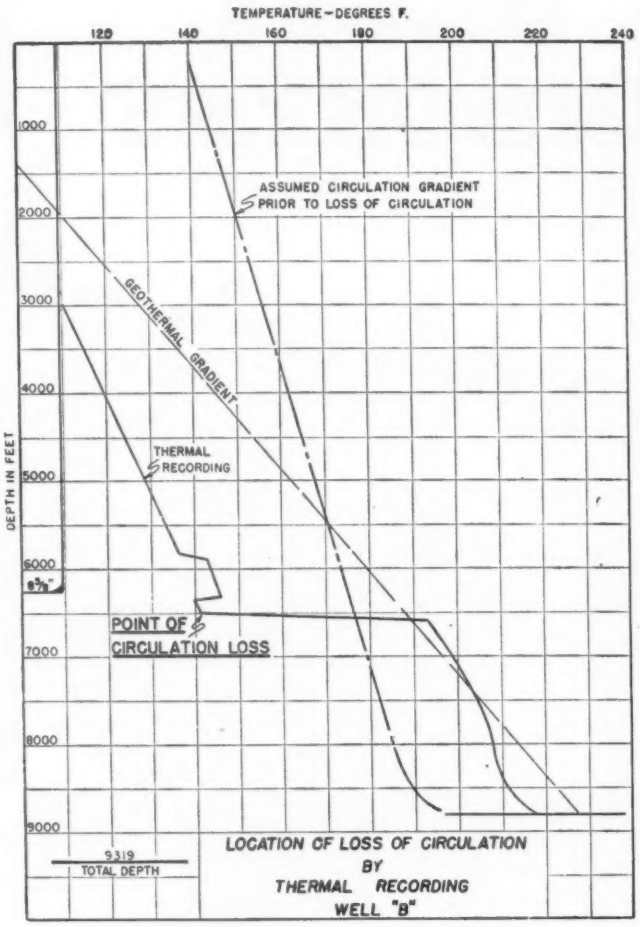


FIG. 2



"Well "A" had a protective string of 11¾-in. casing cemented at 5533 ft; 8⅝-in. water string cemented at 7029 ft; 6⅝-in. liner hung 6998-8225 ft, perforated overall from 7419-8225 ft. The 3-in. tubing had previously been pulled to 4437 ft for an unsuccessful flowing "waterwitch" run.

A portable compressor was used to depress the column of salt water between the 8⅝-in by 11¾-in. annulus to the point of leak, thereby establishing a flow of gas down the annulus and into the 8⅝-in. casing. While gas lifting the well in this manner, the well was produced through the 8⅝-in. casing. At the time of the run the well was producing at a rate of 475 bbl of gross fluid, 8.5 per cent cut; circulated gas, 1150 M cu ft, formation gas 500 M cu ft; 835 psi tubing pressure, 645 psi casing pressure, 1800 psi (estimated) input circulation pressure. The well was gas lifted in this manner for approximately 18 hr to insure equilibrium conditions. It is believed that an adequate temperature anomaly was established in 5 or 6 hr after breaking circulation through the leak.

One temperature traverse was made to record in the interval from 4700 ft to 7200 ft. The survey indicated a marked temperature anomaly of 13 F at 5535 ft. (See Fig. 1). Using a packer, the location of the leak was confirmed as being between 5538 ft and 5540 ft by circulating 2½ cu ft of fluid per min under a pressure of 2000 psi. From subsequent thermal work, it may be stated that the same anomaly would have been recorded had the tubing shoe been below the point of leak.

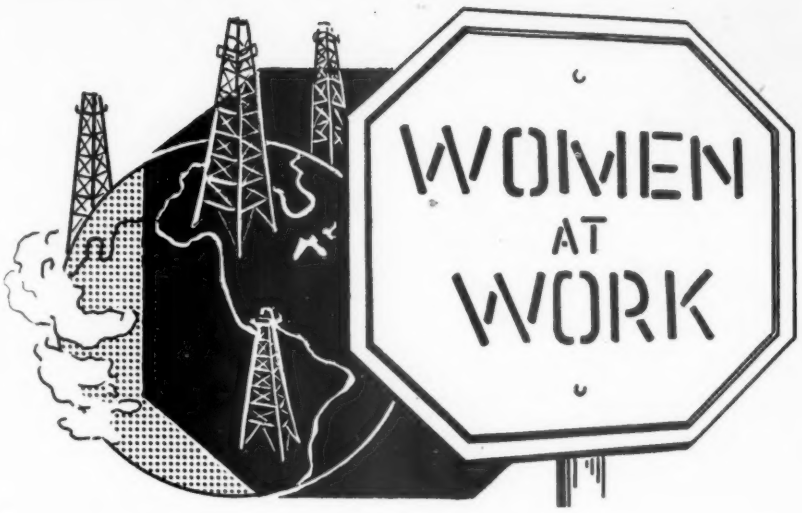
The continuous recording instrument used is a self-contained precision unit that records on a high temperature photographic film. The film permits projection on a greatly enlarged scale, which facilitates interpretation of the survey record.

The completed survey was given on a scale of 1 in. equals 25 ft. In Fig. 1 the survey has been redrawn to permit inclusion of the entire survey from 4700 ft to 7200 ft. The variation from a straight line above and below the point of anomaly did not exceed 2 F from the straight lines shown in Fig. 1.

● **Method of determining point of lost circulation in a drilling well.** Conditions encountered in the drilling of 10,000-ft wells resulted in a decision to locate points of lost circulation in a drilling well by means of a thermal survey and thereby eliminate the costliness of random cementation.

An illustration of one of the surveys is shown in Fig. 2. Casing of 8⅝ in. diam had been set at 6286 ft. While drilling at 9319 ft, circulation was lost completely. It required 185 bbl of mud to fill the hole. Due to an elapsed time of approximately 7 hr, 100 bbl of mud was pumped in and forced away just prior to the survey in order to have a pronounced temperature anomaly at the point of loss. It will be seen from Fig. 2 that this was an unnecessary precaution since an abnormally high temperature change of 52 F was recorded. It had been assumed that the hole temperature at the time of the survey approximated the geothermal gradient above and below the leak. By pumping 100 bbl of mud, approximately 1600 lineal ft in the 8⅝-in. casing, it was estimated that the gradient above the point of loss would retain the same slope but the temperature would be lowered approximately 17 F at all depths above the point of loss.

Taken from the article, "Thermal surveys applied to oil field problems," by Henry G. Abadie. Published in *The Petroleum Engineer*. June, 1947, pages 47 and 48, inclusive.



Officer Feeney — fourth of a series?

Noted Micropaleontologist–

It would be hard to estimate the value of brilliant **Alva Ellisor's** work—to the oil industry and to the women geologists that followed her. She was the first woman to do subsurface microscopic geology for an oil company. That was in 1918 after she had earned a degree from the University of Texas, had taught geology and was on the Kansas State Geological Survey. Humble Oil and Refining Company engaged Alva to study well samples at Cisco, Texas, and soon after famous Wallace E. Pratt, chief geologist with Humble, hired the young woman as a geologist on his staff.

From 1927 to 1947, when she retired, Alva Ellisor devoted all her time to research in stratigraphy and micropaleontology and the industry has benefitted from her published works. She went from state to state collecting samples, working hard and late on this subject that to her was always interesting, absorbing and challenging. The company respected her inquiring mind and her independent thinking. Her research problems were of her own choosing and she earned the admiration and approval of her associates.

"Maybe I was just lucky in having a marvelous opportunity come my way at the right time—during the most colorful era of the oil industry," said the geologist, who by her industry and intelligence paved the way for other women in oil geology.

That wasn't luck—that was destiny, having the right woman probing into the secrets of subsurface formations when this research was most needed.

Montana Lease Hound

If anyone could get more involved in the oil business than pretty **Lois Bailey,** she would have to have 25 hours in her day. With more than a decade in the oil business, Lois has handled royalties and leases and at one time operated a producing lease. Now she is co-owner of the Montana Oil Journal in Great Falls; a partner in Landowners Royalties Company, royalty brokerage firm, and a partner in the firm of Raymond and Bailey, dealers in oil leases. She is actively engaged in the oil business to a greater extent than any other woman in Montana and perhaps in the Rocky Mountain region.

Due to her connection with the royalty and lease firms named above, her oil interests in Montana are state-wide, including farms, mineral rights, and royalties in every county in the state east of the Rockies.

Lois, a member of the Great Falls Desk and Derrick Club, has been in oil long enough to be firmly convinced that any other line of endeavor would be a boring way of making a living.

Esso Export Official

Margaret M. Feeney is the first woman officer of Esso Export Corporation, world-wide marketing affiliate of Standard of New Jersey. She was elected secretary of the company by the board of directors.

A native New Yorker and former school teacher, Miss Feeney has been associated with the Jersey Standard organization for eight years. She has served as secretary of Esso Export's executive committee since 1948 and as assistant corporation secretary for the past two years. Margaret has BA and MA degrees from Mount St. Vincent College and Fordham University, both of New York. She served as a secretary in the U. S. War Department before she joined Jersey Standard in 1945.

The election of Miss Feeney gives the Jersey Standard organization its fourth woman corporate officer and reflects its policy to recognize and utilize the executive talents of women employees. Since 1945, Miss Muriel E. Reynolds and Mrs. Margery M. Porter have served as assistant secretaries of Standard Oil Company (New Jersey). And since 1946 Miss Alice Bartles has been assistant secretary of Standard Oil Development Company, central research affiliate of Jersey Standard. All three began their careers with the Jersey Standard organization as stenographers.

Alva Ellisor conducted micropaleontology research.

Lois Bailey is publisher and royalty-lease broker.

XUM

Only Carlon*

FOR SALT WATER DISPOSAL

Only CARLON Plastic Pipe effectively resists corrosion from salt water and other corrosive wastes. It is completely impervious to the effects of sulphurous waters, alkalies, sour crude and hydrochloric acid used to acidize disposal formations. Guaranteed forever against rot, rust and electrolytic action, CARLON Plastic Pipe successfully serves installations where ordinary metal pipe is continually replaced.

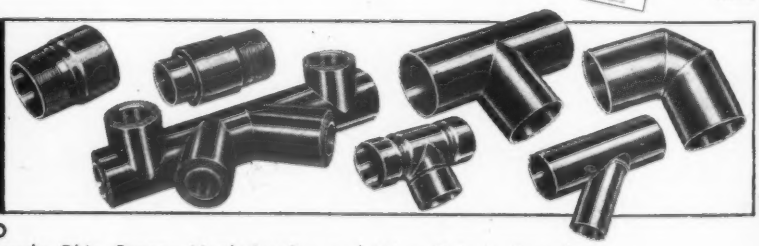
Extremely lightweight (only 1/8th as heavy as steel), CARLON can be installed in less time and with less effort. It is supplied in long lengths which require fewer fittings per installation. Permanent, leakproof connections can be made to existing metallic lines by means of plastic fittings and without special tools.

For economical salt water disposal piping that *lasts* . . .
specify CARLON Plastic Pipe. *Write today for literature.*

* The First REAL PIPE that is Plastic! • BUY THE PIPE WITH THE STRIPE!

1396-CP

CARLON PRODUCTS CORPORATION
Pioneers in Plastic Pipe



10[illegible] MEECH AVENUE • CLEVELAND 5, OHIO
CARLON plastic pipe is produced in Texas, Colorado, Ohio, Oregon, North Carolina and Acton, Ontario, Canada.

Photo courtesy Van Hook of Friden Co.

Texan was early in the oil game.

Rig Climber

When the big oil boom was on at Breckenridge, Texas, a cute little towhead with energy to burn played on rigs and watched the pipe go down. The men teased her at times and asked her what she was going to be. If she had said then, "I'm going to be an oil woman," she would have been a prophet.

After **Maxine Campbell** got out of Breckenridge High School and Ranger Junior College, she worked for Pitzer and West Oil Company and got her basic training in oil accounting and general oil field information. She moved to Abilene, Texas, in 1947 and went to work for V. C. Perini, Jr., geologist and oil producer. Maxine is office manager and accountant. She pays lease rentals, goes over division orders for correct interests, checks production and prepares Texas Railroad Commission forms, handles correspondence, and a few dozen other things.

Not only does she keep as busy as a jet bit in the office but she dives into housework and cooking at home with the same willing spirit, a fact fully appreciated by her husband and evidently by their loyal English bulldog.

Maxine, a director of Abilene Desk and Derrick, doesn't have time to play on rigs nowadays but she goes out to look at one occasionally when the club sponsors a field trip.

Where Credit Is Due

Look to your credit when you encounter **Pearl M. Dolan.** She has to be smart enough to tell who is good for his bills in her job as assistant credit manager and manager of the accounts receivable department with Fleet-Wing Corporation in Cleveland, Ohio.

When asked about herself Pearl goes into an enthusiastic account of Fleet-Wing. Fleet-Wing, according to Pearl, was organized over a quarter of a century ago as a subsidiary of Standard of Ohio, to supply independent marketers. It was the original marketer of gasoline treated with tetraethyl lead, which was offered exclusively to independents.

After high school and business courses at Cleveland and Fenn Colleges, Pearl joined Standard of Ohio as a bookkeeper in 1927, then in 1935 went to Fleet-Wing. She is a member of the American Petroleum Credit Association, has served on the board of the Cleveland Association of Credit Men, is past president of the Cleveland Credit Women's Club, is charter member and past president of the Cleveland Desk and Derrick Club, belongs to the Business Women's Club, and is active in the Christian Educational work of the East Cleveland Baptist Church.

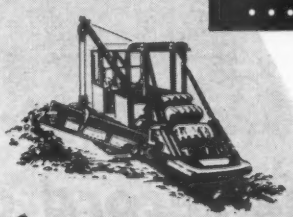
"Credit, marketing, and distribution problems of the petroleum jobber are vitally interesting and there is no monotony in my job." Pearl declares. She likes to travel better than anything. Could this be because it helps gasoline sales?

Credit Whiz Dolan at right.

It takes a FULL team

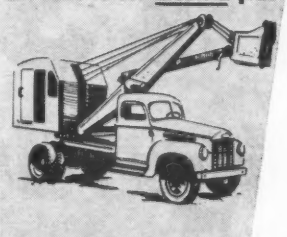
. . . whether it's surgery

. . . or digging equipment



1. This is for big jobs

2. This is for medium jobs



3. Sherman for all other jobs

On many excavating jobs the use of big equipment is costly and time-consuming. The Sherman Power Digger is designed so that you get all the advantages of power digging on these jobs. Thousands of users have proved that the Sherman Power Digger reduces costs. Write today for descriptive literature 56.

Designed, Engineered and Manufactured Jointly by

SHERMAN PRODUCTS, Inc.
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Patent No. 2,303,825
Other patents pending

Sherman

PRODUCTS, INC.
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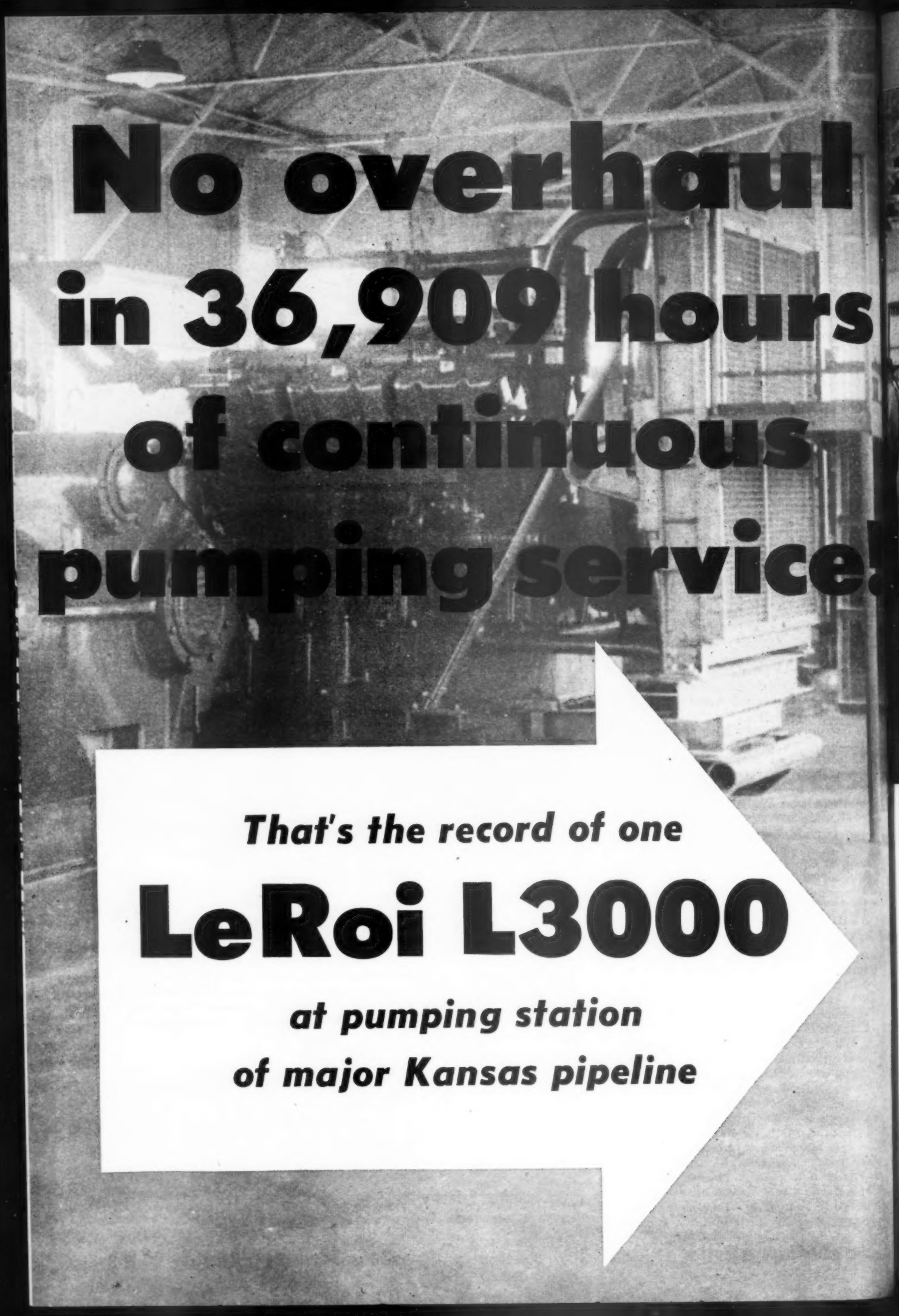
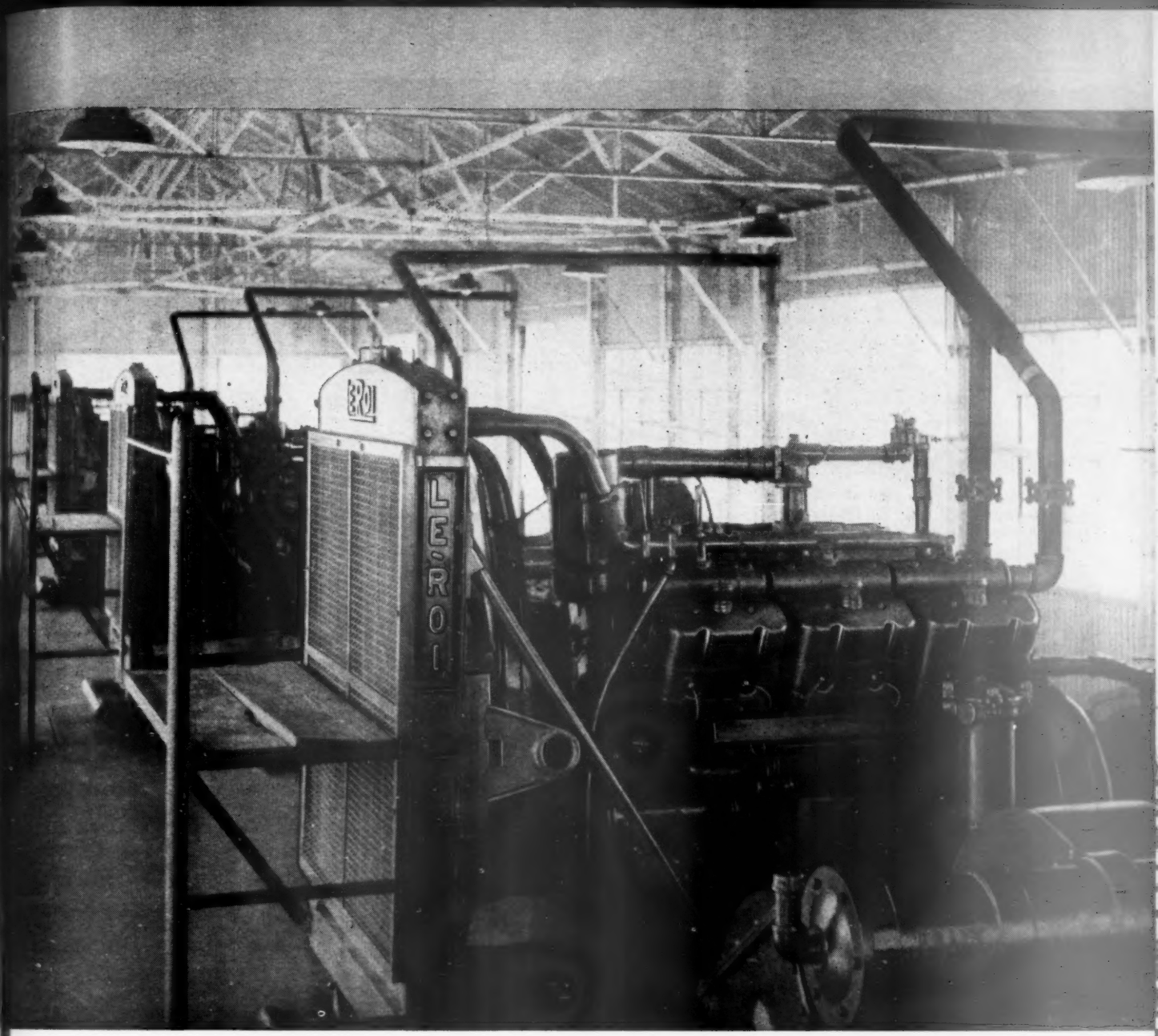
Sherman SP Products


No overhaul
in 36,909 hours
of continuous
pumping service!
That's the record of one
LeRoi L3000
at pumping station
of major Kansas pipeline



The figures speak for themselves...

Le Roi leads in dependability! Le Roi leads in economy!

If you're interested in cutting your costs for pipeline pumping, here are figures you simply can't afford to ignore:

In the installation pictured above, one of the Le Roi L3000's operated continuously for more than 4 years — under an average load of about 200 hp — before needing overhauling! And then labor amounted to only $373 and parts to only $1578.

A second Le Roi L3000 at the same station operated continuously for 33,615 hours — under the same load — before it had to be overhauled! Labor for the overhaul cost only $476 and parts only $1305.

Now, these aren't isolated cases. In fact, another Le Roi L3000 installed at a different pumping station of this same pipeline company had over 39,500 hours' service and had never been overhauled!

Want to see profitable performance like that at first hand? Ask your supply house or Le Roi distributor to take you around to some Le Roi installations. Have them show you why more and more Le Roi's are being installed for pipeline and other oil-field service.

LE ROI COMPANY

A Subsidiary of Westinghouse Air Brake Co.

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Oil Field Headquarters: Tulsa Oklahoma

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Skilled mechanics on 24-hour call
. . . Unexcelled overhaul facilities

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Le Roi Company Branch — Tulsa
Carson Machine & Supply Co.—Oklahoma City

East & South Texas, Gulf Coast
Southern Engine and Pump Company—Houston, Kilgore, Edinburg, Dallas, San Antonio, Corpus Christi, Texas, and Lafayette, Houma, Louisiana.

North & West Texas, New Mexico
General Machine & Supply Co. — Odessa, Snyder, Texas.
Nortex Engine & Equipment Co. — Wichita Falls, Texas.

Kansas
Carson Machine and Supply Co. — Great Bend

Illinois — Western Kentucky
Western Machinery & Engine Company — Centralia, Illinois and St. Louis, Missouri.

Michigan
Hafer Engine Service — Reed City

Rocky Mountain Area
Gehring Equipment Co. — Casper, Wyoming, Rangeley, Col.

Mississippi, Arkansas & Northern Louisiana
Ingersoll Corporation — Shreveport, Louisiana, El Dorado, Arkansas, and Clarksdale, Jackson, Mississippi.

West Coast
Le Roi-Rix Machinery Co. — Los Angeles, Long Beach and Bakersfield, Calif.

Appalachian Area
P. C. McKenzie Co., Pittsburgh, Bradford.

Canada
Lucey Export Ltd.—Calgary, Edmonton, Alberta.

P-12

XUM

Statement on Iran Oil Cargoes Clarified

A communication has been received from the Anglo-Iranian Oil Company to clarify a statement made in a news story on Page E-2 of the August issue of The Petroleum Engineer. The story concerns shipments of oil from Iran. One paragraph states: "Three legal decisions have been handed down, with the company's claim to ownership of cargoes upheld in one." The communication is in clarification of this statement and says:

"No court in the world has ruled against Anglo-Iranian on question of ownership of oil shipped from Iran, and Aden (Italy) supreme court fully supported Anglo-Iranian's claim to title when it sued an Italian company shipping Iranian oil. When Iranian oil was landed in Japan and Italy Anglo-Iranian applied in local courts for orders prohibiting sale of the oil pending conclusion of legal proceedings to determine its ownership, and although these applications were refused, the main cases concerning ownership of oil have yet to be heard in both Italy and Japan."

Digby, Conservative Democrat Given 5-Year Term on FPC

S. L. Digby has been nominated and approved for a five-year term on the Federal Power Commission. An independent democrat, Digby was approved by the Republican national committee and by the Democrats for Eisenhower organization in Louisiana.

The five-member FPC has three Republicans on its board now and is required by law to have two members of another party to make up the Commission. Digby replaces Harrington Wimberly as a Democratic member of the commission.

Although Digby supported Adlai Stevenson in the past presidential campaign, Governor Shivers of Texas and Kennan of Louisiana, who were strongly behind Eisenhower, supported Digby's appointment.

Digby was a former Louisiana state district judge from 1948 to 1952 and a member of the Louisiana Conservation Commission. He is said to believe strongly in private enterprise and is reported as a conservative influence in Washington.

Gwynne Gives FTC Republican Majority

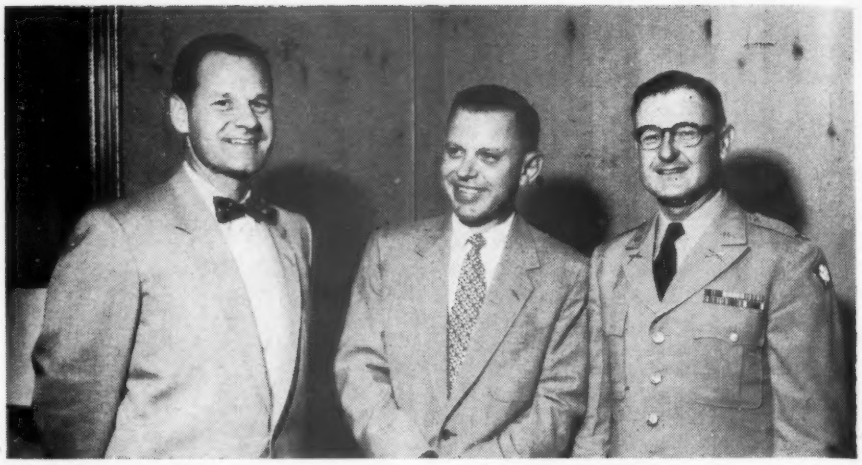
Representative John W. Gwynne, a Republican from Iowa, has been named to the Federal Trade Commission to succeed Stephen A. Spingarn, Democrat, whose term expires this month.

The appointment gives Republicans a clear majority on the FTC. Gwynne is a former judge and prosecutor from Waterloo, Iowa, the birth place of Edward F. Howrey, FTC's new chairman.

Howrey replaced John Carson, former official of the Cooperative League of the U. S.

Spingarm spoke loud and long against the alleged oil cartel, and is described as being a strong New Dealer. The other Democrats on the Commission are Mead and Carretta.

New appointments to the FTC are expected to be more favorable to business.



FOREIGN GUESTS and eighty Houston Nomads gathered at College Inn in Houston on July 13 to hear a discussion on industrial photography by Photographer Bob Bailey. Foreign guests present are: G. L. Von Hillo, Shell C. P. C., Maracaibo; Fred W. Haeseker, Asiatic Petroleum Corporation, Houston; Colonel Kirk P. Brock, U. S. Army, Europe.

U. S. Domestic Crude Oil Stocks Rise

United States crude oil stocks rose to 279,611,000 bbl in the week ended August 8, the Bureau of Mines reported. This was a rise of 467,000 bbl from the week before.

Stock rise was due to increase in inventories in domestic crude, which rose 598,000 bbl, as foreign crude stocks in the U. S. dropped to 10,162,000, a total of 131,000 bbl.

Louisiana had largest increase in stocks with Kansas and Oklahoma following.

Senate Agrees to New Tideland Legislation

Herbert Brownell, Jr., attorney general of the U. S., has reported that he will ask the District of Columbia Federal Court to dismiss the state of Arkansas's suit against the recently passed legislation returning coastal states' ownership of the tidelands. Brownell reported that the Government will contend that Arkansas has no right to challenge federal laws.

The suit asked that the law be declared null and void that federal officials be restricted from turning back to the coastal states the $50,000,000 of royalty and other payments held in escrow following Supreme Court decisions.

A new bill passed by the House has been agreed to by the Senate. This bill eliminates provision for revenues for Federal aid to education. Applying to the areas beyond the state-owned tidelands, the bill bars coastal states from sharing any of the continental shelf oil revenue, and prohibits them from levying taxes in the area. State police and civil laws will extend beyond the federal area unless they are in conflict with federal law and regulations, however.

Esso to Try Underground Storage of Fuel Oil

Esso Standard Oil Company has announced a new program to use several large abandoned quarries for fuel oil, a move to put underground fuel oil storage nearer areas where it is used. Much talk has been going on about storage and its need in case of emergency. Because oil can be produced faster than it can be consumed, ample storage space for surplus oil is essential. Cost of enough tanks to store all oil that could be produced in this country, even if steel were available, would be prohibitive.

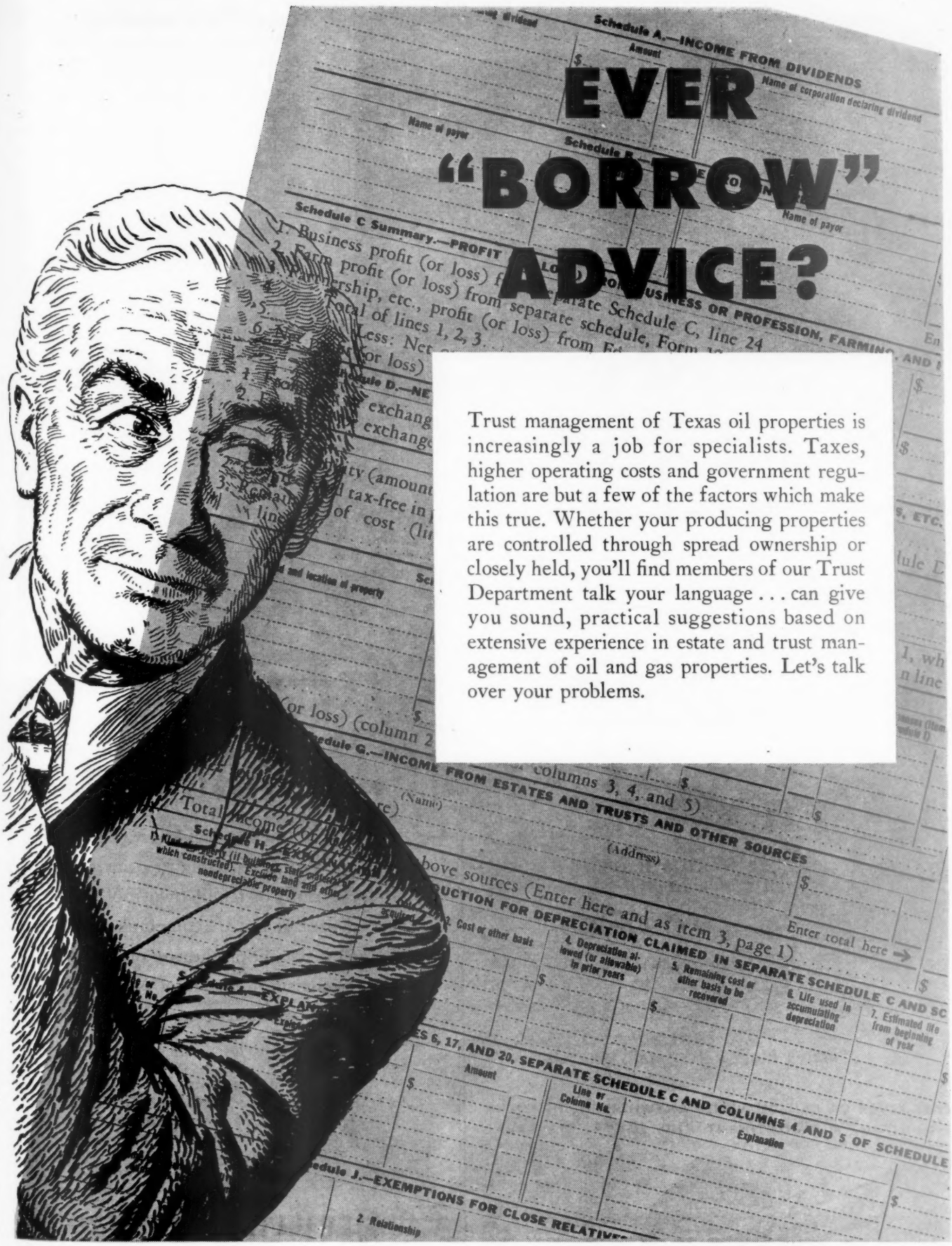
Liquefied petroleum gas was stored in underground crevices last year by Lion Oil and other companies. Last winter Lion stored more than 2,500,000 gal of liquefied petroleum gas in salt strata below the ground. This helped supply users during the winter rush season.

Experiments to date on underground storage have proved too expensive for small companies. If adopted it would have to be hendled by major oil companies and/or the government.

U. S. Oil Output Sets January Record

World crude petroleum production during January averaged a record 12,816,000 bbl daily, the fifth successive month of production records, although the January daily average rate was less than one per cent above that of December. During January, small declines in the United States and Venezuela were offset in the Middle East. Total Middle East daily average production, 2,296,000 bbl, a record for the area, was 7.2 per cent above the December rate.

Crude imports into western Europe, totaling 1,435,000 bbl daily during January, averaged 2.4 per cent under the December daily figure. Declines occurred in all the major importing countries in January, the largest being in The Netherlands, where daily average imports were only 72.7 per cent of those in the previous month.


EVER
"BORROW"
ADVICE?
Trust management of Texas oil properties is increasingly a job for specialists. Taxes, higher operating costs and government regulation are but a few of the factors which make this true. Whether your producing properties are controlled through spread ownership or closely held, you'll find members of our Trust Department talk your language . . . can give you sound, practical suggestions based on extensive experience in estate and trust management of oil and gas properties. Let's talk over your problems.

MERCANTILE NATIONAL BANK
AT DALLAS

MEMBER FEDERAL DEPOSIT INSURANCE CORPORATION

INTERNATIONAL guests at August meeting of Los Ange.es Chapter of Nomads. Standing: H. G. Goethe, Deutsche Erdoel A. G., Germany; P. K. Ozinga, Shell, Venezuela; Bob Bryan, Santa Fe Drilling, Kuwait; Haraldo R. da Silva, D. and E., Brazil; C. M. White, Iraq Petroleum, Iraq. Seated are: K. G. Long and Vernon F. Clayton, Iraq Petroleum; Migual Baca, Santa Fe Drilling; Cope Johnson, Servicio Thomas.

L. A. Nomads Visit Long Beach Harbor Oil Development

The regular monthly dinner meeting of the Los Angeles Chapter of Nomads in August was preceded by a trip through the Long Beach Harbor, the oil operations there being inspected on land and from the water. Engineered by Frosty Martin, president of the Board of Harbor Commissioners, Nomads and their guests were first shown the effects of subsidence and the vast operation of filling in the land and raising the producing wells 20 ft and more.

Crude Prices Adjusting

Crude oil prices were up in some parts of the country and down in some parts. Gulf Exploration Company, subsidiary of Gulf Oil, has reduced its posted price for Kuwait crude oil to $1.75 a barrel from $1.72 a barrel. Price is retroactive to July 16, and is for 31 gravity crude.

Mid-East Crude Sales, Ltd., which sells Arabian crude for Standard of California and The Texas Company, has announced that its Arabian crude oil, recently increased 15 cents a barrel has been dropped back 5 cents. No reason was given for this cutback, but the announcement followed a similar cut by Anglo-Iranian Oil.

In Canada, Imperial Oil, Ltd., has raised its gasoline 1.4 cents per gallon in wholesale prices in all of that country except British Columbia where prices went up a half cent a gallon.

The new prices reflect recent advances in competitive crude oil prices in the U. S. and the higher exchange value of the U. S. dollar.

Joseph Seep Purchasing Agency of South Penn Oil Company's purchasing agency has anounced it is increasing the price of Pennsylvania grade crude oil 13 to 15 cents a barrel, depending on grade. A spokesman from the company reported that these new prices will correct differentials in delivery costs that have been unbalanced by tariff rates and regulations.

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(FLAKE, SOLID, LIQUID)

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Our technical and financial knowledge of the oil industry is available to principals of independently or family owned oil and gas properties. If you are contemplating a loan against present production or considering the acquisition or sale of producing holdings, our specialized experience may be helpful.

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Oil Department

Empire Trust Company
7 WEST 51st STREET
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API Model Rig Base Offered

A colorful base containing a dramatic cross-section of earth strata, oil traps, and other underground formations is being produced by the American Petro-

leum Institute to supplement the scale-model drilling rig made available to the industry last year.

The 30-in. drilling rig, which is an authentic scale-model, and the cut-away base provide viewers with a graphic picture of how oil men drill through the earth for the powerful liquid which now supplies 62 per cent of the nation's energy requirements.

Both the base section and the rig may be obtained through the Department of Information, API, 50 West 50th Street, New York 20, N. Y.

Justice Department Gets Oil Price Study

The Department of Justice has reported that it is having difficulty finding evidence to prove that the recent price increases in gasoline and crude oil is a result of conspiracy among oil firms.

Assistant Attorney General Stanley N. Barnes, head of the antitrust division, reported that "price increases are receiving careful consideration by the department to determine whether a violation of the federal antitrust laws has been committed."

Price investigations were begun by Representative Heselton and Chairman Wolverton, who are reported studying state proration laws and the Interstate Oil Compact, and their alleged effect on oil prices. The two congressmen have turned the investigation over to the Department of Justice and have urged that it also look into the operations of proration laws and the Oil Compact.

LSU Offers New Course

Louisiana State University is offering a new course of study this fall in answer to industry's demand for more versatile petroleum production engineers.

The new course is the petroleum-chemical engineering curriculum. It is a five-year course which will qualify a graduate for any position in the chemical engineering or petroleum engineering professions.

Awarding a BS degree, the curriculum includes all of the basic work offered in both petroleum and chemical engineering plus a good background in oil sources. It will be jointly supervised by departments of chemical and petroleum.

Mexico Output May Go Up

Antonio J. Bermudez, head of Pemex, Mexico government oil monopoly, has announced that his country expects to produce more than 100,000,000 bbl of oil next year.

Bermudez stated in answer to an article appearing in the British Petroleum Press News Service, which stated that Mexico was not doing enough exploration, that her reserves were going down, and production had only been kept up by an uneconomic exploitation of old fields. Bermudez reported that the 1952 production was 78,000,000 bbl and could have been 84,000,000 if the foreign market had been higher.

The S. D. DAY Company

Serving the Oil and Gas Industry

Pictured here are some typical applications of coating and wrapping products distributed by S. D. Day Company.

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THE RUBEROID COMPANY*
Pipe Line Asbestos Felt

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Hot Applied Coal Tar Enamels for Pipe Lines

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Write, wire or telephone for literature, prices and engineering counsel.

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preferred everywhere for

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in 2½" to 4" pipe work

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NO. 2BR GEARED THREADER

Put this popular Toledo on your 2½" to 4" pipe. Watch it produce perfect tapered threads with *top-speed* . . . and a *minimum of effort.*

EFFICIENT HAND OPERATION . . . Light weight . . . easy handling. Convenient carrying handles. Employs Toledo receding die principle . . . 5 die segments . . . highest quality tool steel . . . three broad faced chuck jaws for easy centering.

HIGH SPEED . . . Operated with a Toledo Power Drive, the 2BR will thread 4" pipe in less than 2 minutes!

ORDER THROUGH YOUR SUPPLY HOUSE . . . Write for catalog 11A-52. The Toledo Pipe Threading Machine Co., Toledo, Ohio. New York Office: 165 Broadway, Room 1310.

Rely on the Leader

TOLEDO

PIPE TOOLS . . .
POWER PIPE MACHINES . .
POWER DRIVES

Mechanical Engineers Meeting In Houston This Month

Greater problems and new developments in the engineering phases of the entire petroleum industry will be covered by the American Society of Mechanical Engineers in its petroleum division annual meeting in Houston September 28-30, according to announcements of the program by H. E. Degler, publicity secretary.

Three dozen papers are divided about equally among refining and petrochemical, pipeline and transportation, and drilling and production divisions of the industry. Subjects covered will include properties of metals and equipment, gas compression, piping technology, catalytic cracking and reforming, design of equipment, pumping, instrumentation, and plant inspection and maintenance. The entire program is included below:

ASME Petroleum Division Meeting
Houston, Texas (Rice Hotel)
September 28-30, 1953

Monday, September 28

Casing Design: "Effect of High Strength Casing and Casing Joints on Design of Casing Strings," by H. Reynolds, field engineer, National Tube; "Triangulation Method for Determining Collapse Change Points in Casing Design," by R. L. Kastor, mechanical engineer, Shell.

New Processes: "Salient Mechanical Features of Houdriflow," by Shirk and Arden, engineers, Houdry Corporation. "Fluid Catalytic Hydroforming Units—Their Mechanical Design," by R. A. Harang, project engineer, M. W. Kellogg. "Continuous Wax Molding," by Ray Shannon, junior engineer, Magnolia.

Compressor Drivers: "Gas Turbine Application for Gas Transmission Lines," by S. Sawyer, senior engineer, El Paso Natural Gas. "Experiences with Tri-Fuel Engines in Pipe Line Service," by Meade and Jennings, Phillips.

Hot Tapping and Branch Reinforcement of Piping: "Design of Hot Tap Connections in High Pressure Pipe Lines," by Del Buono, Vissat and Williams, Taylor Forge. "The Mechanical Aspects of Hot Tapping," by Burt Ver Nooy, chief engineer, Williamson Inc.

Drilling Research: "Theory of Drilling Action of Rotary Rock Bits," by P. A. Szego, professor of mechanical engineering, Rice Institute. "Progress Report on a Fluid Actuated Rotary Percussion Engine," by W. H. Cline Jr., project engineer, Hughes Tool.

Refinery Materials: "Cast Iron in the Refinery," by W. J. Buxton, design engineer, Standard Oil of Indiana. "Why Use Prestressed Concrete in the Refinery," by Bell and De Veaux, Esso Standard.

Tuesday, September 29

Unfired Pressure Vessel Code Forum: "ASME Pressure Vessel Code—A Joint Effort for Safe Construction," discussion led by E. O. Bergman, Braun and Company. Panel members: H. C. Boardman, H. B. Oatley, Walter Samans, and F. S. G. Williams.

Equipment Design: "Application of Roller Bearings in Oil Field Equipment," by S. M. Weckstein, chief engineer, Timken Company. "High Pressure Nitriding and its Applications to the Petroleum Industry," by Chenault and Mohnkern, engineers, Oil Well Supply.

Well Head Equipment: "Test Data and Conclusions on Casing Hanger Slip Capacity," by E. F. Cooke, Jr., manager of engineering, Beaumont Iron Works. "Automatic Self-Sealing Gate Valves," by A. F. Rhodes, director of engineering, McEvoy.

Pipe Line Pumping Control: "Micro-Wave Control of Pumping Stations," by R. C. Cheek, electronics engineer, Westinghouse Corporation. "Application of Reciprocating Pump Valve Lifters to Closed Systems Operation," by Nigh and Llewellyn, Service Pipe Line.

New Developments in Gas Compressors: "New Developments in Compressor Equipment Design and Performance for Natural Gas Transmission Pipe Line Service," by B. T. Mast, supervising engineer, Tennessee Gas Transmission. "Packaged Compressor Plants," by E. S. McRoberts, J. B. Beaird Company.

Rig Operations: "Formation of Martensite on Rotary Drilling Lines," by C. M. Zerr, chief engineer, Union Wire Rope. "Hard Facing Tool Joints," by J. A. Crawford, mechanical engineer, Signal Oil and Gas.

Wednesday, September 30

Instrumentation for Pipe Line Control: "A Capacitance-Sensitive Recorder for Pipe Line Applications," by Howard and En Dean, Gulf Research Company. "Use of Radio-active Isotopes in Pipe Line Interface Marking," by Kohl and Newacheck, engineers, Tracerlab, Inc.

Materials and Methods: "Monel Protection for Off Shore Structures," by T. P. Mag, International Nickel Company. "Pipe Line Welding Standard," by A. G. Barkow, engineer, Texas-Illinois Natural Gas Pipe Line.

Refinery Inspection and Maintenance: "Water Cleaning of Exchangers," by W. B. Thomas, mechanical engineer, Texas Company. "Preventive Maintenance of Refinery Compressors," by J. R. Ware, maintenance engineer, Magnolia.

Drilling Equipment: "Power Transmission on Rotary Rigs by Friction, Fluid, and Electromagnetism," by M. L. Rizzone, Oil Well Supply. "A Practical Approach to Vibration Problems on Drilling Barges," by T. B. Herndon and A. B. Reese, Jr., National Supply.

Pipe Line Stress Analysis: "Introductory Problems Encountered in the Use of Strain Gages," by Nuttall and Goodrich, Electronic Engineers, United Gas Pipe Line Company, Shreveport. (This paper presented in two sections).

Refractory Linings for Pressure Vessels: "Monolithic Linings for Vessels and Pipes," by W. A. Bradbury, mechanical engineer, Humble Oil. "Factors Influencing the Performance of Internal Insulating Linings," by Vogrin and Murphy, engineers, M. W. Kellogg.

U. S. Oil Imports Stay Below 1,000,000 Bbl Daily

The American Petroleum Institute has reported that imports of oil products into the United States totaled 880,200 bbl daily for the week ending August 8. This was slightly under the 929,900 reported the week before. The week of June 27 was the last time imports went over the 1,000,000 per day mark.

Below are figures for the last four weeks as reported by API:

Week ended	Crude oil	Residual oil	Distillate fuel oil asphalt, others	U. S. total
July 18.....	617,200	206,300	19,100	842,600
July 25.....	598,200	318,400	22,400	939,000
August 1....	639,500	270,800	19,600	929,900
August 8....	672,500	202,700	5,000	880,200

Oil Firms' Earnings Show Rise for First Half of 1953

On the basis of a majority of half-year reports from various oil firms 1953 net earnings in the first 6 months were substantially increased over the first half of 1952. Although some in the larger firms had slightly less than last year, same period, 14 reported net gains.

The mid-year refining strike cut heavily into profits for the first six months last year. The new price increase in both crude oil and products came too late to be figured in on the first half year income.

Below is list of oil companies showing net incomes for first half of 1953 and 1952:

Company	Net income—first 6 months 1953	1952
Anderson-Prichard	$ 2,116,307	$ 2,191,502
Ashland Oil	57,351,941	55,287,530
Bishop Oil	96,066	51,667
Cities Service	28,384,862	27,120,714
Derby Oil	542,912	362,399
Douglas Oil	639,286	614,573
Deep Rock	618,000	522,000
Gulf Oil	75,761,000	66,981,000
Honolulu	4,708,331	3,833,196
Houston Oil	3,352,210	3,010,224
Quaker State Oil	966,872.67	894,778.96
Lion Oil	2,405,572	2,218,427
Panhandle Oil	193,225.03	398,811.83
Phillips Petroleum	34,224,846	38,933,442
Socony Vacuum	88,000,000	84,000,000
South Penn Oil	3,328,515	3,743,977
Standard Oil of California	91,373,736	87,159,717
Standard Oil of Jersey	261,000,000	265,000,000
Standard of Ohio	8,506,364	7,736,289
Sun Oil	21,659,462	21,413,293
Texas Company	29,223,997	27,177,567
Texas Gulf	1,788,846	1,636,552
Union of California	17,807,464	13,333,234

Oil Depletion Tax Studied

The oil depletion law is being studied in Washington but without any antagonism. It is a part of an overall study of the federal tax structure.

Speaking before the U. S. Congress, General Ernest O. Thompson of the Texas Railroad Commission stated there was not half enough ready reserve oil sources for national security, and urged continuance of the 27½ per cent depletion tax allowance granted producers.

James P. Jones, independent oil spokesman of Bradford, Pennsylvania, reported to Congress that the tax depletion allowance is essential to numerous small producers faced with high cost and financially hazardous production operations.

Safety Awards Granted

Continental Oil Company has won the National Safety Council's "Award of Honor," for its over-all 1952 safety record, the council has informed J. S. Boylan, director of Continental's safety division.

The award is presented to a company whose safety record is better than the national oil industry record, and better than the company's record for three years preceding the year in which the award is given. No oil company received the Award of Honor in 1951.

Phillips Petroleum Company has received the National Safety Council's Award of Honor, for significant achievements reflected in the company's 1952 safety record of accident reduction.

Scientifically controlled tests, impartially conducted, to determine the comparative accuracy of several flowmeters of popular designs have conclusively proved the superior advantages of Barton's Dual-Bellows meter body. The Barton was the only flowmeter that averaged less than 1% deviation from perfect calibration over a 100°F change in meter temperature; others tested deviated as much as 3%. The ingeniously engineered Barton Meter Body insures a higher order of accuracy when the instrument is subjected to normal day and night air temperature variations.

Sustained accuracy is one outstanding Barton flowmeter advantage. In addition, the actuating element is compact, rupture-proof, yet highly sensitive, insuring a long life with high responsiveness. Problems associated with mercury, pressure bearings and over-ranging are eliminated.

Externally adjustable pulsation dampner eliminates pen flutter and chart painting. Torque tube drive assures absence of leakage and friction. Barton flowmeters are completely self-draining, or venting...need no sealpots. *Install cost-cutting Barton flowmeters.*

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*Pat. Nos. 2400048, 2500360, 2590324, other patents pending.

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Personals

James S. Weatherby, a senior research economist for the Atlantic Refining Company, Philadelphia, has been named chief of the Domestic Petroleum Branch of the Petroleum Administration for Defense, Deputy Administrator Joseph A. LaFortune announced.

After studies at the University of Pennsylvania, Weatherby went with The Atlantic Refining Company in 1929. In 1942 he went into military service. Discharged in 1946, at which time he was executive officer in the Army's Sub Area Petroleum Office in the Western Pacific Area, he rejoined Atlantic.

William F. Kirk, assistant manager of General Petroleum Corporation's economics department, has been appointed assistant director of the Program Division of PAD.

Until taking over as assistant director of the division, Kirk is serving as special assistant to the director of the program division.

Kirk took his BS at Oregon State College in 1929. He joined General Petroleum after his graduation and has been employed by the company since that time.

Marion E. Dice, manager of General Petroleum Corporation's economics department and member of the executive committee, celebrated his 30th anniversary of company service during July. Company executives and associates, including R. L. Minckler, General Petroleum president, recently gave a luncheon for Dice in Los Angeles, in recognition of his service record.

Dice was originally employed as a draftsman in 1923. He has held his present post since 1944.

Dean C. Wellman has been named manager Rocky Mountain area for The Derby Oil Company with offices in Denver, Colorado. Wellman has been in charge of the Denver office since its opening two years ago. **Roland R. Toevs** of Derby's Wichita land department has been temporarily transferred to the Denver office as landman for this area.

Dr. Richard V. Hughes

Jack A. Crichton

D. C. Langford

Dr. Richard V. Hughes has been appointed technical assistant to the vice president, Gulf Oil Corporation, Houston division, succeeding **Paul Weaver** who retired recently.

Dr. Hughes came with Gulf in June, from Stanford University where he had served successively as visiting lecturer, professor and head of the department of petroleum engineering since 1949.

He attended the University of Nebraska, receiving the bachelor of science degree in civil engineering there in 1925. He was awarded his doctorate in geology from Johns Hopkins.

Dr. Hughes has worked for Tropical Oil Company in Colombia and Lago Petroleum in Venezuela.

Jack A. Crichton has been named president, Oil and Gas Property Management, Inc., and vice president, Empire Trust Company, with offices in the Fidelity Union Life Building, Dallas, Texas. Crichton is a past vice president and director of DeGolyer and MacNaughton, Dallas, Texas, and a past vice president and director of San Juan Oil Company, Dallas, Texas. He has a BS degree from Texas A. & M., a master's degree from the Masstachusetts Institute of Technology, and a Professional Degree from Texas A. & M.

D. C. Langford has been named general manager, Canadian Palmer Stendel Oil Corporation, Calgary, Alberta. Before joining the corporation Langford was, for a number of years, manager of the petroleum and natural gas division of The Canadian Bank of Commerce in Calgary.

Elihu Madison, manager of the economics department of The Texas Company, was named director of the Program Division of the Petroleum Administration for Defense, Deputy Petroleum Administrator Joseph A. LaFortune announced. Madison took his degree in business administration at the University of Texas. He received a master's degree in business administration in 1936 and a doctor's degree in 1952 from New York University. He has worked for The Texas Company since 1929.

L. S. Collins, a veteran of 37 years with The Carter Oil Company was elected a vice president by the Carter board of directors. Collins, who began his oil career as bookkeeper with Carter in Tulsa in 1916, became assistant chief accountant three years later, served 20 years as comptroller and has been a director since 1940. He attended Oklahoma A. & M. College.

Thomas J. Garin of Oil City, Pennsylvania, former newspaperman, has been appointed curator of Drake Well Memorial Park in Titusville, succeeding Dr. Paul H. Giddens.

Giddens was appointed the Park's first curator in 1942 and served while a member of the faculty of Allegheny College, Meadville. He resgined after accepting the presidency of Hamline University, St. Paul, Minnesota.

Garin received the bachelor of arts degree from St. Bonaventure University in 1933.

Rocco C. Siciliano, supervisor of labor relations for Procon Incorporated, has been confirmed by the Senate as an assistant secretary of labor.

Siciliano, who also was assistant secretary of Procon, construction subsidiary of Universal Oil Products Company, is expected to take over his new duties in a short time.

The new assistant secretary of labor is a lawyer and former legal assistant to a member of the National Labor Relations Board in Washington.

Left,
V. B. Harris

Right,
Mac D. Oliver

Virgil B. Harris has been elected a director and vice president in charge of operations, and **Mac D. Oliver** has been elected a director and vice president in charge of engineering of San Juan Oil Company of Dallas. Harris, who has been with the company for the past two years, was formerly with Core Laboratories, Inc., and a district superintendent of Barnsdall. He is a graduate of Texas A & M. He has also been named petroleum engineer and geologist for the Texas Consolidated Oils, which is operated by San Juan.

Oliver, who has been with the company for 2½ years, is a graduate of Texas A & M and formerly with the firm of Cable and Stine in Wichita Falls.

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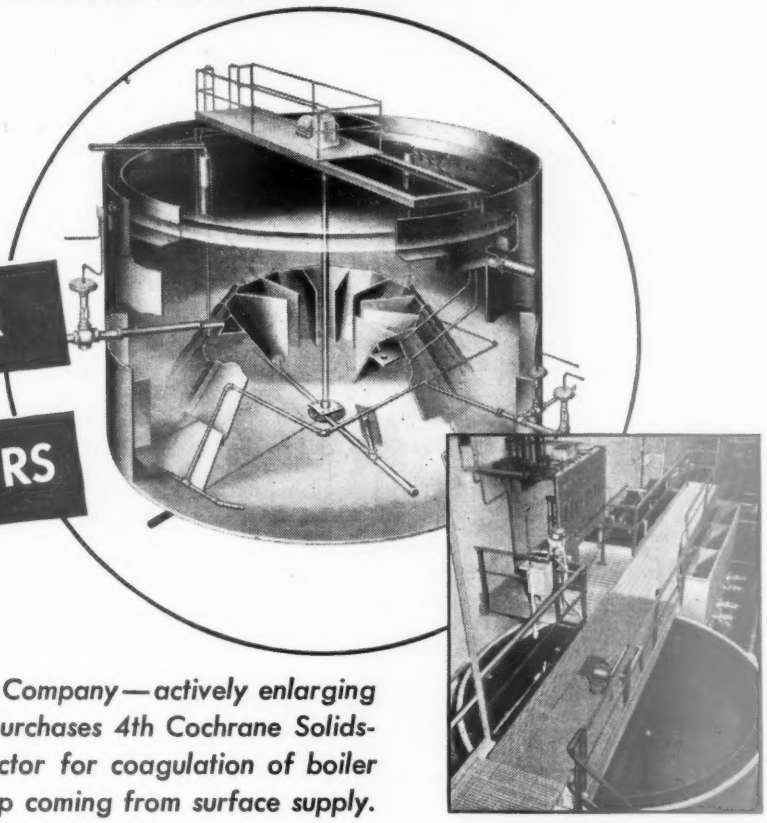

Duke Power Company—actively enlarging capacity—purchases 4th Cochrane Solids-Contact Reactor for coagulation of boiler feed make-up coming from surface supply.

• This record of repeat orders is evidence of successful design and performance. Units are being built for coagulation, lime softening, iron removal, fluoride removal, white water recovery in paper mills, cooling water treatment, process water clarification, tin plate rinse water, oil field flooding water and similar applications.

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Personals

▸ **W. E. Lovejoy** has been appointed assistant to the manager in the safety division of Standard Oil Company of California's personnel department, San Francisco. Previously personnel supervisor for the California Research and Development Company, a subsidiary, Lovejoy has been with Standard since 1924. He is a graduate of the University of Washington.

▸ **Jerry Luboviski** has been appointed assistant to the vice president, public relations and advertising, for Union Oil Company of California. For the past five years Luboviski has been public relations representative for the Western Oil and Gas Association.

▸ **Ralph C. Farley,** formerly Tulsa, Oklahoma, division superintendent of Ohio Oil, has been appointed manager of production of the Tide Water Group operations in Saskatchewan, Canada, in which Ohio Oil has a substantial interest. Transferred to Ohio Oil's foreign division and assigned to special duty with Tide Water Associated Oil Company, operator of the project, Farley is in charge of drilling, producing, and petroleum engineering operations. **H. M. Kirk** is general manager of the project.

H. N. Lewis, formerly Ohio Oil's district superintendent at Chickasha, Oklahoma, succeeds Farley as Tulsa division superintendent.

Farley joined Ohio Oil pipe line department at Del Rio, Texas, in 1926. He was appointed Shreveport division superintendent in 1944, and became Tulsa division superintendent in 1950.

Lewis began with Ohio Oil as a pumper in 1921 in Oklahoma. He was appointed district superintendent at Bridgeport, Illinois, in 1947 and at Chickasha, Oklahoma, the following year.

▸ **Curtis Morris,** vice president of Transcontinental Gas Pipe Line Corporation, Houston, will join the executive staff of the American Gas Association on October 1, managing director **H. Carl Wolf** has announced.

Wolf said that Morris initially would study AGA's facilities and services devoted to natural gas production and transmission. He is expected to make recommendations looking to the association's greatest possible usefulness to producing, transmission and distributing natural gas companies.

Morris attended public schools in Washington County, Ohio. He received his BA degree from Ohio University and his MA degree from University of Colorado.

He joined Transcontinental in its formative days, April 1, 1949. He handled legislative, tax, and public relations for the company. He was engaged in tax and legislative work in Texas prior to joining Transcontinental and represented Texas public and private agencies in Washington in the Tidelands case.

▸ **R. L. Hazlett,** editor of the Beacon, employee magazine of The Ohio Oil Company, has been appointed assistant to the company's public relations manager, M. S. Hauser. **E. L. Price,** assistant editor of the Beacon succeeds Hazlett as editor.

A journalism graduate of the University of Colorado, Hazlett for eight years edited and published a weekly oil trade paper, The Inland Oil Index, Casper, Wyoming, covering Rocky Mountain oil and gas industry news. He joined Ohio Oil as Beacon editor in 1946.

Price, formerly cub reporter of the Toledo News-Bee and columnist for the Hancock County News, began his career with Ohio Oil in 1935 as a service station attendant. He was appointed assistant editor of the Beacon in 1944.

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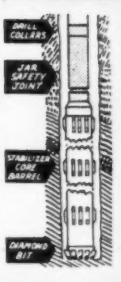

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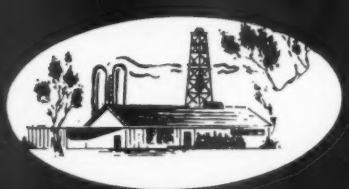
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ELIMINATE PITTING AND CORROSION... *Like This!*

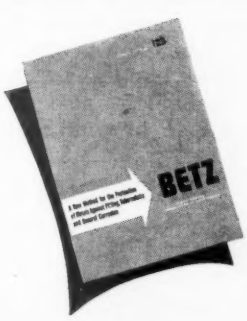
It's no secret that one of the biggest headaches of corrosion control in cooling water systems is the continuance of pitting and tuberculation. Many conventional water treatment methods attempt to overcome this problem by the use of excess treatment concentrations. However, this has been found to be expensive and not altogether successful.

But here's welcome news: Betz Laboratories, after long and careful research, has developed the Dianodic Method which positively assures freedom from scale, protection against corrosion and *elimination of pitting and tuberculation!*

Basically, the Dianodic Method consists of employing a combination of two anodic inhibitors in such a way as to produce results superior to any present water treatment. This advanced technique effectively eliminates pitting and tuberculation, and at the same time provides increased protection against general corrosion.

Results are outstanding! A plant employing polyphosphate treatment encountered severe corrosion, tuberculation and plugging of heat exchangers with corrosion products. Tubercles from ½ to 3 inches in length were found throughout the entire system. Often it was necessary to drill some of the heat exchangers at 30 day intervals to remove accumulated corrosion products. Then the Betz Dianodic Method was used. It was necessary to set up a cleaning program after the application of the Dianodic Method to remove the sloughed off corrosion products that accumulated. After three months operation, this cleaning program was discontinued. *No new pitting or tuberculation has occurred!* Heat exchangers are now inspected and cleaned only at the normal annual turn around.

This is just one example of how Betz *Specialized* Water Conditioning Service is increasing efficiency and cutting costs in plants throughout industry. Why not let Betz show you how to improve results at *your* plant? There's no obligation on your part. W. H. & L. D. BETZ, Gillingham & Worth Streets, Philadelphia 24, Pa. In Canada: Betz Laboratories Limited, Montreal 1.



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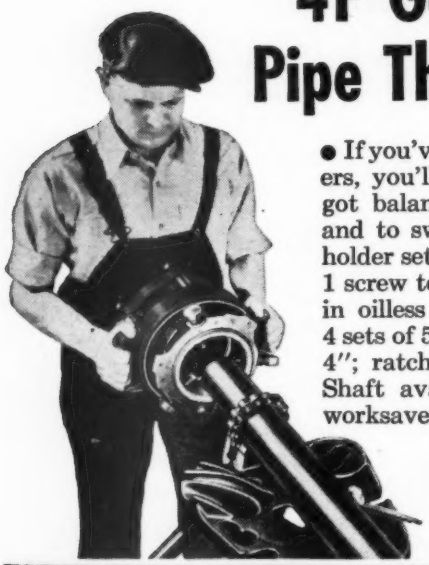

● If you've rassled with old-style geared threaders, you'll go strong on this RIDGID 4P. It's got balanced loop handles—a cinch to carry and to swing onto pipe. Mistake-proof workholder sets to size before it's put on pipe—only 1 screw to tighten. Easy upkeep—drive pinion in oilless bronze bearing; safe enclosed gear. 4 sets of 5 high-speed steel dies, 2½", 3", 3½", 4"; ratchet handle. RIDGID Universal Drive Shaft available — also 4P for conduit. Buy worksaver 4P at your Supply House.

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DEATHS

Owen Fuller Thornton, petroleum engineer formerly of Houston, Texas, died in New Orleans, Louisiana, July 15, after an extended prolonged illness. Thornton was vice president of the Louisiana Land and Exploration Company.

He received his technical training at Oklahoma A & M, where he received his bachelor and master's degrees. While in Houston he was employed by the Tidewater and Texas companies, and served as head of the AIME section in 1949.

Dr. Alphons Otto Jaeger, of American Cyanamid Company, died suddenly July 21. Dr. Jaeger held hundreds of patents on important chemical manufacturing processes which he developed during his 40-year career in the chemical industry.

Dr. Jaeger was born in Bergzabern, Germany, coming to the United States in 1923 as a research chemist and group leader of National Aniline and Chemical Company. In 1929 he was elected vice president of Seldon Company when that firm merged with American Cyanamid Company.

H. R. Bennett, 57, vice president and director of Union Producing Company and director of United Gas Pipe Line Company, was stricken with a heart attack and died August 19, while playing golf at the Shreveport Country Club. The attack came without warning on the third green and death was almost instantaneous.

Bennett joined Union Producing Company as a vice president and director in February, 1946. In October, 1947, he was elected a director of United Gas Pipe Line Company.

His experience in the oil and gas business dates from 1921, when he became associated with an independent operator in Houston, Texas. He held an executive position with Mills Production Company of Houston for several years before joining Union Producing Company.

Marcel Schlumberger, co-founder of the Schlumberger Well Surveying Corporation died in Paris, France, August 20. With his brother Conrad, Schlumberger founded the Schlumberger Well Surveying Corporation after research in electrical logging of oil wells. Marcel became president of the corporation in 1936, when his brother, Conrad, died, but turned the presidency over to his son Pierre in 1946.

Clyde E. Greeson, a laboratory technician in engineering and research department of Mid-Continent Petroleum Corporation, died August 15 in Tulsa, Oklahoma. He was 63 and had been with Mid-Continent for 10 years.

G. A. Gamble, president of Woodbine Oil Corporation, died August 19 at his home in Dallas, Texas. A resident of Dallas, Gamble founded the corporation of which he was the head.

TON MILES

5½-in. drill pipe — 24.7 lb. per foot

20,000 lb EXCESS WEIGHT

DEPTH	0	100	200	300	400	500	600	700	800	900
0	0	1	2	2	3	4	5	6	8	9
1000	9	11	12	14	15	16	18	19	21	22
2000	24	26	27	29	30	33	35	37	39	40
3000	43	45	47	49	51	53	56	58	60	63
4000	65	68	70	73	76	78	81	84	87	89
5000	92	95	98	101	104	107	111	114	117	120
6000	124	127	130	134	137	141	144	148	152	155
7000	159	163	167	171	175	179	183	187	191	195
8000	199	203	208	212	216	221	225	230	235	239
9000	243	248	253	257	262	267	272	277	282	287
10000	292	297	302	307	312	317	323	328	333	339
11000	344	350	355	361	367	372	378	384	390	395
12000	401	407	413	419	425	431	438	444	450	456
13000	463	469	475	482	488	495	501	508	515	521
14000	528	535	542	548	555	562	569	576	584	591
15000	598	605	612	620	627	634	642	649	657	664
16000	672	680	687	695	703	711	718	726	734	742
17000	750	758	766	775	783	791	799	808	816	824
18000	833	841	850	859	867	876	885	893	902	911
19000	920	929	938	947	956	965	974	983	992	1002

25,000 lb EXCESS WEIGHT

0	0	1	2	3	4	5	6	8	9	10
1000	12	13	15	16	18	19	21	23	24	26
2000	28	30	32	33	35	37	40	42	44	46
3000	48	50	53	55	58	60	63	65	68	70
4000	73	76	78	81	84	87	90	93	96	99
5000	102	105	108	111	115	118	121	125	128	131
6000	135	138	142	146	149	153	157	161	165	168
7000	172	176	180	184	189	193	197	201	206	210
8000	214	219	223	228	232	237	241	246	251	255
9000	260	265	270	275	280	285	290	295	300	305
10000	311	316	321	326	332	337	342	348	354	359
11000	365	371	377	382	388	394	400	406	412	418
12000	424	430	436	443	449	455	461	468	474	481
13000	487	494	500	507	514	520	527	534	541	548
14000	555	562	569	576	583	590	597	604	612	619
15000	626	634	641	649	656	664	671	679	687	694
16000	702	710	718	726	734	742	750	758	766	774
17000	782	791	799	807	816	824	833	841	850	858
18000	867	876	884	893	902	911	920	929	938	947
19000	956	965	974	983	993	1002	1011	1021	1030	1039

30,000 lb EXCESS WEIGHT

0	0	1	2	4	5	6	8	9	11	12
1000	14	15	17	19	20	22	24	26	28	30
2000	32	34	36	38	39	42	44	47	49	51
3000	54	56	59	61	64	67	69	72	75	78
4000	80	83	86	89	92	95	98	102	105	108
5000	111	115	118	121	125	128	132	135	139	143
6000	146	159	154	158	162	166	169	173	178	182
7000	186	190	194	198	203	207	211	216	220	225
8000	229	234	239	243	248	253	258	263	267	272
9000	277	282	287	293	298	303	308	313	319	324
10000	330	335	340	346	352	357	363	369	374	380
11000	386	392	398	404	410	416	422	428	434	441
12000	447	453	459	466	472	479	485	492	498	505
13000	512	519	525	532	539	546	553	560	567	574
14000	581	588	595	603	610	617	625	632	640	647
15000	655	662	670	678	685	693	701	709	717	725
16000	733	741	749	757	765	773	781	790	798	806
17000	815	823	832	840	849	857	866	875	883	892
18000	901	910	919	928	937	946	955	964	973	983
19000	992	1001	1011	1020	1029	1039	1048	1058	1067	1077

EXAMPLE: Ton miles per round trip at depth of 12,500 ft with 5½-in., 24.7 lb drill pipe and 25,000 lb excess weight = 455.

Courtesy Wickwire Rope, The Colorado Fuel and Iron Corporation

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- Body and stem guide extra heavy bar stock fused into one piece.
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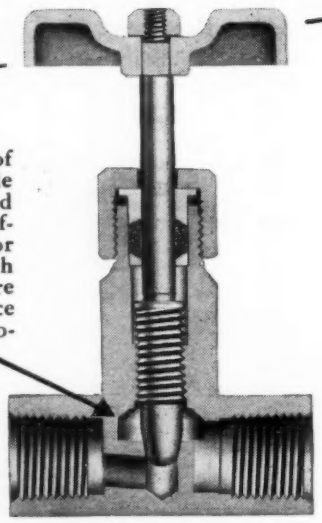

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The Ultimate in Needle Valves

Here is one of the crowning achievements of Marsh research, design, and manufacturing skill. It is the first needle throttling and shutoff valve to combine *all* of the qualities called for today in this highly critical and ever broadening field.

It is a valve that has strength and safety to spare . . . rated for pressures up to 10,000 psi—equally efficient in the lower ranges. A product of Marsh instrument-making and valve manufacturing experience, it combines instrument-like precision with the ruggedness that distinguishes all Marsh valve specialties.

The illustrations tell the story of new thinking; new standards. Body and stem-guide are machined from extra-heavy carbon steel bar stock. Still greater strength and rigidity are achieved by fusing the stem-guide into the body. The complete fusion of guide and body is accomplished by the exclusive Marsh "Conoweld" process.

There are two big advantages to this one-piece construction: (1) It eliminates the danger of unscrewing the valve from the body when opening—a frequent cause of leakage, even dangerous blow-outs (2) It permits perfect line-up of threads and seat. As a result, Marsh valves are easier to operate even at high pressures.

The precision-machined stem is 416 stainless steel. Stem threads are fine pitch for extra strength and fine, controlled regulation. Notable advancements are special "Marpak" one-piece, non-binding longer-lasting packing; deep thread chambers, keeping inlet and outlet piping away from ports and contributing excellent flow characteristics. Entire packing nut and packing gland are electro-zinc plated, preventing corrosion and giving the valve a handsome, plated exterior. The rugged malleable handle is finished in heavy baked enamel.

The new needle valve line includes globe and angle patterns with double female connections in sizes ⅛", ¼", ⅜", ½", ¾" and 1". Also globe and angle valves with male inlet and female outlet in sizes ¼" and ½". *Complete stock carried at our Skokie, Illinois factory and also at our branch plant in Houston, Texas.*

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Houston Branch Plant: 1121 Rothwell St., Sect. 15, Houston, Texas

MARSH

"THE STANDARD OF ACCURACY"

TON MILES

5½-in. drill pipe — 24.7 lb. per foot

35,000 lb EXCESS WEIGHT

DEPTH	0	100	200	300	400	500	600	700	800	900
0	0	1	3	4	6	7	9	10	12	14
1000	16	17	19	21	23	25	27	29	31	33
2000	35	38	40	42	44	47	49	52	54	57
3000	60	62	65	68	70	73	76	79	82	85
4000	88	91	94	97	101	104	107	110	114	117
5000	121	124	128	131	135	139	142	146	150	154
6000	158	162	166	170	174	178	182	186	190	195
7000	199	203	208	212	217	221	226	230	235	240
8000	245	249	254	259	264	269	274	279	284	289
9000	294	300	305	310	315	321	326	332	337	343
10000	348	354	360	366	371	377	383	389	395	401
11000	407	413	419	425	431	438	444	450	457	463
12000	469	476	483	489	496	502	509	516	523	530
13000	536	543	550	557	564	571	579	586	593	600
14000	608	615	622	630	637	645	652	660	668	675
15000	683	691	699	707	714	723	730	739	747	755
16000	763	771	779	788	796	804	813	821	830	838
17000	847	856	864	873	882	891	899	908	917	926
18000	935	944	953	964	972	981	990	1000	1009	1018
19000	1028	1037	1047	1057	1066	1076	1085	1095	1105	1115

40,000 lb EXCESS WEIGHT

0	0	2	3	5	6	8	10	12	14	16
1000	17	19	21	24	26	29	30	32	34	37
2000	39	42	44	47	49	52	54	57	60	62
3000	65	68	71	74	77	80	83	86	89	92
4000	96	99	102	105	109	112	116	119	123	127
5000	132	134	138	141	145	149	153	157	161	165
6000	169	173	177	182	186	190	194	199	203	208
7000	212	217	221	226	231	235	240	245	250	255
8000	260	265	270	275	280	285	290	295	301	306
9000	311	317	322	328	333	339	345	350	356	362
10000	367	373	379	385	391	397	403	409	415	421
11000	428	434	440	447	453	459	466	472	479	486
12000	492	499	506	512	519	526	533	540	547	554
13000	561	568	575	583	590	597	604	612	619	627
14000	634	642	649	657	665	672	680	688	696	704
15000	712	720	728	736	744	752	760	768	777	785
16000	793	802	810	819	827	836	844	853	862	870
17000	879	888	897	906	915	924	933	942	951	960
18000	969	979	988	997	1007	1016	1026	1035	1045	1054
19000	1064	1074	1083	1093	1103	1113	1123	1133	1143	1153

45,000 lb EXCESS WEIGHT

0	0	2	4	5	7	9	11	13	15	17
1000	19	20	23	26	28	31	33	36	38	40
2000	43	46	48	51	53	56	59	62	65	68
3000	71	74	77	80	83	87	90	93	96	100
4000	103	107	110	114	117	121	125	128	132	136
5000	140	144	148	151	155	160	164	168	172	176
6000	180	185	189	194	198	202	207	212	216	221
7000	225	230	235	240	245	250	255	260	265	270
8000	275	280	285	290	296	301	307	312	317	323
9000	329	334	340	345	351	357	363	369	374	380
10000	386	392	399	405	411	417	423	429	436	442
11000	449	455	462	468	475	481	488	495	501	508
12000	515	522	529	536	543	550	557	564	571	578
13000	586	593	600	608	615	623	630	638	645	653
14000	661	669	676	684	692	700	708	716	724	732
15000	740	748	756	765	773	781	790	798	807	815
16000	824	832	841	849	858	867	876	885	893	902
17000	911	920	929	939	948	957	966	975	985	994
18000	1004	1013	1022	1032	1041	1051	1061	1071	1080	1090
19000	1100	1110	1120	1130	1140	1150	1160	1170	1180	1190

EXAMPLE: Ton miles per round trip at depth of 12,500 ft with 5½-in., 24.7 lb drill pipe and 35,000 lb excess weight = 502.

Courtesy Wickwire Rope, The Colorado Fuel and Iron Corporation

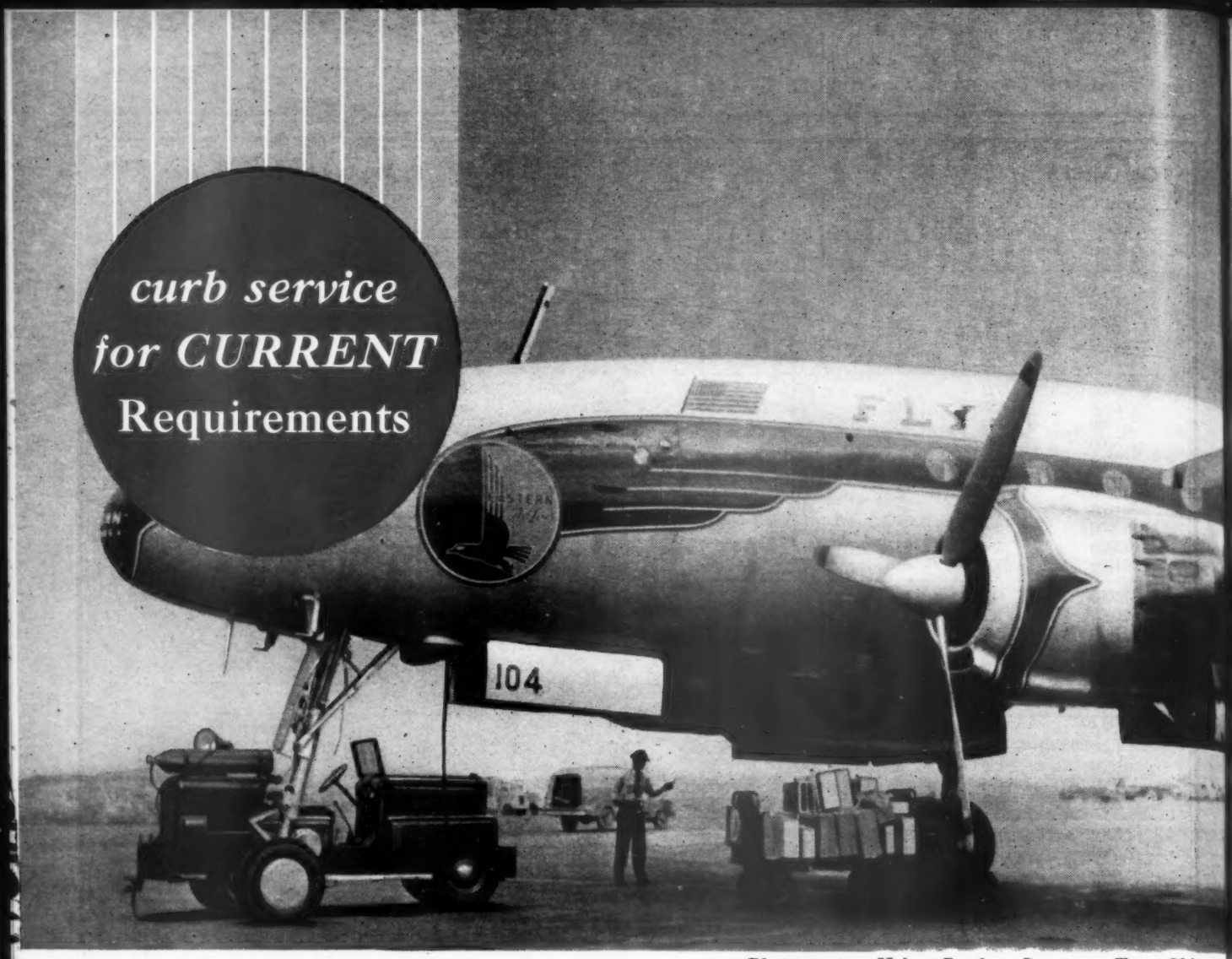
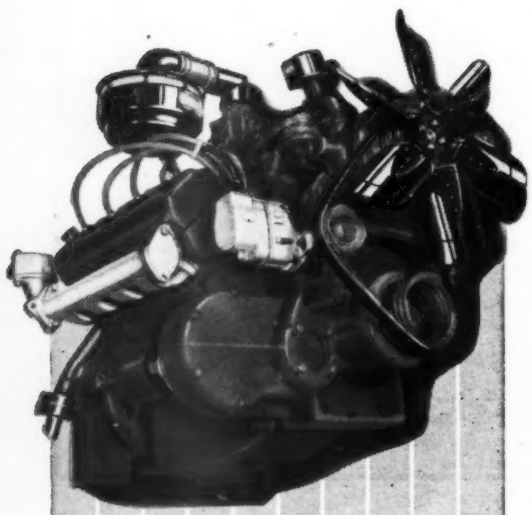


Photo courtesy Hobart Brothers Company, Troy, Ohio

Chrysler horsepower on the ground for added Safety in the Air . . .



The moment the big plane stops and the pilot cuts the engines, the generators, which in flight supply electrical power to the batteries, stop too. But the electrical equipment in the plane—air conditioning, lights, radio, food containers, everything electrical—continue operating off the plane's batteries. Only for a moment, however. In that length of time a self-propelled and self-powered energizer takes over and supplies all necessary current, even starting the plane's engines when it's time to leave.

Among the most popular mobile ground power units are the "Power-Pull" units manufactured by Hobart and powered by Chrysler. The unit pictured uses the mighty 180 horsepower Chrysler V-8 Industrial Engine and can furnish 1000 amperes, 28.5 volts of direct current under continuous operation—enough to handle the electrical load of the largest aircraft. Power from the same engine propels the unit, enabling it to serve also as a towing tractor.

This is another in the long list of important uses of Chrysler Industrial Power. Whether your equipment requires V-8 or Six cylinder engines, Chrysler can supply them with gasoline, propane or natural gas burning carburetor, 3, 4 or 5-speed transmission and other optional equipment.

For your power needs, see a Chrysler Industrial Engine Dealer, or write: ***Dept. 179, Industrial Engine Division, Chrysler Corporation, Trenton, Michigan.***

CHRYSLER
Industrial Engines

HORSEPOWER WITH A PEDIGREE

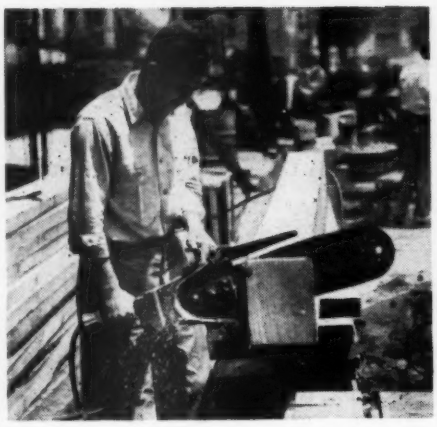
TON MILES

5½-in. drill pipe — 24.7 lb. per foot

DEPTH	0	100	200	300	400	500	500	700	800	900
50,000 lb EXCESS WEIGHT										
0	0	2	4	6	8	10	12	14	17	19
1000	21	24	26	28	31	34	36	39	41	44
2000	47	50	52	55	58	61	64	67	70	74
3000	77	80	83	86	90	93	97	100	104	107
4000	111	114	118	122	126	129	133	137	141	145
5000	149	153	157	162	166	170	174	179	183	187
6000	192	196	201	206	210	215	220	224	229	234
7000	239	244	249	254	259	264	269	274	279	285
8000	290	295	301	306	312	317	323	329	334	340
9000	346	351	357	363	369	375	381	387	393	399
10000	405	412	418	424	430	437	443	450	456	463
11000	469	476	483	489	496	503	510	517	524	531
12000	538	545	552	559	566	574	581	588	596	603
13000	610	618	625	633	641	648	656	664	672	679
14000	687	695	703	711	719	727	735	744	752	760
15000	769	777	785	794	802	811	819	828	836	845
16000	854	863	872	880	889	898	907	916	925	935
17000	944	953	962	971	981	990	1000	1009	1018	1028
18000	1038	1047	1057	1067	1076	1086	1096	1106	1116	1126
19000	1136	1146	1156	1166	1176	1187	1197	1207	1218	1228
55,000 lb EXCESS WEIGHT										
0	0	2	4	7	9	11	13	16	18	21
1000	23	26	28	31	34	36	39	42	45	48
2000	51	54	57	60	63	66	69	72	76	79
3000	82	86	89	93	96	99	103	107	111	115
4000	118	122	126	130	134	138	142	146	150	154
5000	159	163	167	172	176	180	185	189	194	199
6000	203	208	213	217	222	227	232	237	242	247
7000	252	257	262	268	273	278	283	289	294	300
8000	305	311	316	322	328	333	339	345	351	357
9000	363	369	375	381	387	393	399	405	412	418
10000	424	431	437	444	450	457	463	470	477	483
11000	490	497	504	511	518	525	532	539	546	553
12000	560	568	575	582	590	597	605	612	620	627
13000	635	643	650	658	666	674	682	690	698	706
14000	714	722	730	738	747	755	763	771	780	788
15000	797	805	814	823	831	840	849	858	866	875
16000	884	893	902	911	920	930	939	948	957	967
17000	967	985	995	1004	1014	1023	1033	1043	1052	1062
18000	1072	1082	1091	1101	1111	1121	1131	1141	1152	1162
19000	1172	1182	1192	1203	1213	1224	1234	1245	1255	1266
60,000 lb EXCESS WEIGHT										
0	0	2	5	7	10	12	14	17	20	22
1000	25	28	31	34	36	39	43	45	48	51
2000	54	58	61	64	67	71	74	78	81	84
3000	88	92	95	99	103	106	110	114	118	122
4000	126	130	134	138	142	146	151	155	159	164
5000	168	172	177	182	186	191	195	200	205	210
6000	215	219	224	229	234	239	245	250	255	260
7000	265	271	276	281	287	292	298	303	309	315
8000	320	326	332	338	344	350	355	361	367	374
9000	380	386	392	398	405	411	417	423	429	435
10000	443	450	456	463	470	477	483	490	497	504
11000	511	518	525	532	539	547	554	561	568	576
12000	583	591	598	606	613	621	629	636	644	652
13000	660	668	675	683	691	699	708	716	724	732
14000	740	749	757	765	774	782	791	799	808	817
15000	825	834	843	852	860	869	878	887	896	905
16000	915	924	933	942	951	961	970	980	989	998
17000	1008	1018	1027	1037	1047	1056	1066	1076	1086	1096
18000	1106	1116	1126	1136	1146	1156	1167	1177	1187	1198
19000	1208	1219	1229	1239	1250	1261	1271	1282	1293	1303

EXAMPLE: Ton miles per round trip at depth of 12,500 ft with 5½-in., 24.7 lb drill pipe and 55,000 lb excess weight = 597.

Courtesy Wickwire Rope, The Colorado Fuel and Iron Corporation



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Charts for Dished Head Areas

TYLER G. HICKS

In material cost estimates, pressure vessel design, and determination of weights of tanks, the area of a dished head is often required. Standard tables of tank dimensions do not contain this information. As a result the area must be computed. The curves shown simplify these calculations.

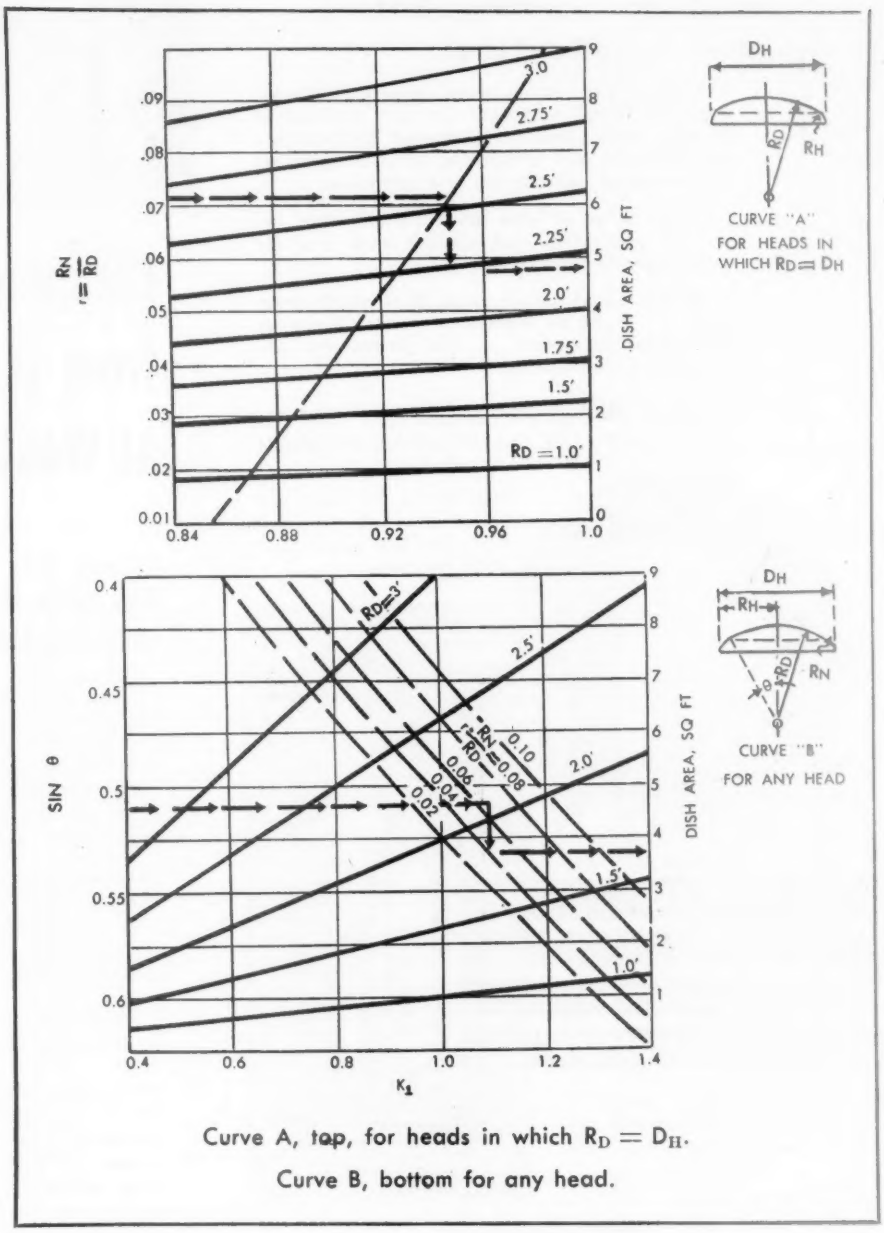
Example 1: Find the area of a 27-in. diam dished head when the knuckle radius is $1\frac{5}{16}$ in. and the dish radius 27 in. The ratio, $r = \frac{RN}{RD} = \frac{1.9375}{27}$ $= 0.0714$. Since dish radius equals head diameter, enter curve "A" at $r = 0.0714$ and project across horizontally until the dashed curve is intersected. From this point vertically to the 2.25-ft dish radius curve and run across horizontally and read 4.8 sq ft.

Example 2: Find the area of a 24-in. dished head which has a 22-in. dish radius and a 1½-in. knuckle radius. The ratio. $r = \frac{1.50}{22} 0.068$ and

$$\sin\theta = \frac{R_H - R_N}{R_D - R_N} = \frac{12 - 1.50}{22 - 1.50}$$

$= 0.51$. Since $R_D \neq R_H$, curve B must be used. Enter at $\sin\theta = 0.51$ and project horizontally across to a dashed curve, $r = 0.068$, lying between $r = 0.06$ and $r = 0.08$. From this point drop vertically to the dish radius of 1.83 ft and then run across to the area, 3.7 sq ft.

When the dish radius is greater than the values covered by these charts, head area can be found from $A_H = K\,(R_D)^2$ and $A_H = K_1\,(R_D)^2$. The constants K and K_1 appear at the bottom of the charts A and B, respectively.



Curve A, top, for heads in which $R_D = D_H$.

Curve B, bottom for any head.

Derivation of Chart

Chart A is based on the relation

$$A_H = KR_D^2 = 2\pi\left[\, r\left\{\frac{\pi}{2}(1-r)\sin\theta - \theta\,(1-r)\sin\theta + r\cos\theta\right\} + (1-\cos\theta)\right] R_D^2$$

Chart B is based on the relation

$$A_H = K_1R_D^2 = 2\pi\left[\, r\left\{\frac{\pi}{2}(1-r)\sin\theta - \theta\,(1-r)\sin\theta + r\cos\theta\right\} + (1-\cos\theta)\right] R_D^2$$

Both relations can be derived using calculus. What the charts do is to reduce the long geometric expressions to simple constants which are easy to apply.

Constants K and K_1 were obtained using API-ASME dished head standards. Two curves were used to simplify the calculations for each type of head. * * *

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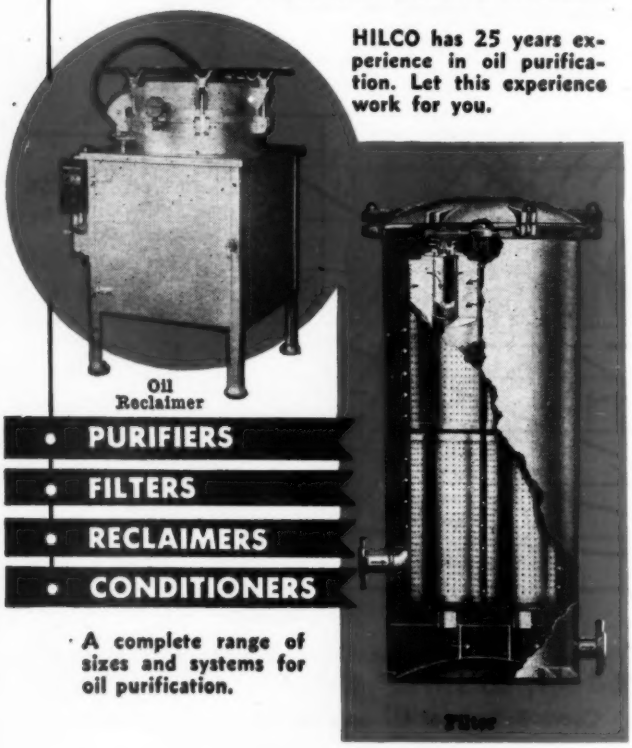

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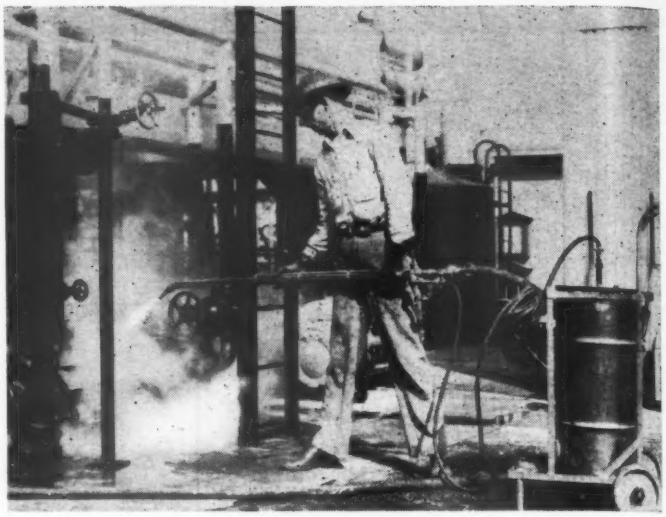

Cleaning Maintenance Cut from Days to Hours at Western Refinery

Refinery finds Oakite Detergent applied with Oakite Steam Gun makes short work of cleaning prior to repainting.

THE cleaning problem this California refinery had was simple enough. It was one of removing all dirt, grease and muck from tanks, pumps and similar equipment. But actually doing the job was not so simple. It meant tedious scraping, wirebrushing, wiping by a sizable crew. It involved struggling with hard-to-get-at surfaces. Did the Oakite Man have a better answer?

He did—as a result of his wide refinery cleaning experience. For this particular case, he suggested the Oakite 384 Steam Gun. He helped Maintenance get started that morning. By afternoon, the plant superintendent stated, "One man did about two weeks' work today".

Proving that—
in industrial cleaning it always pays to consult Oakite.

YOUR OAKITE TECHNICAL SERVICE REPRESENTATIVE.—His experience is yours to draw on. He knows "cleaning engineering" and the conditions under which refinery cleaning can be best performed. His responsibility only *begins* when you order materials. He keeps in touch with you. He sees to it that the job is done right the first time, at lowest cost. Call him in . . . no obligation.

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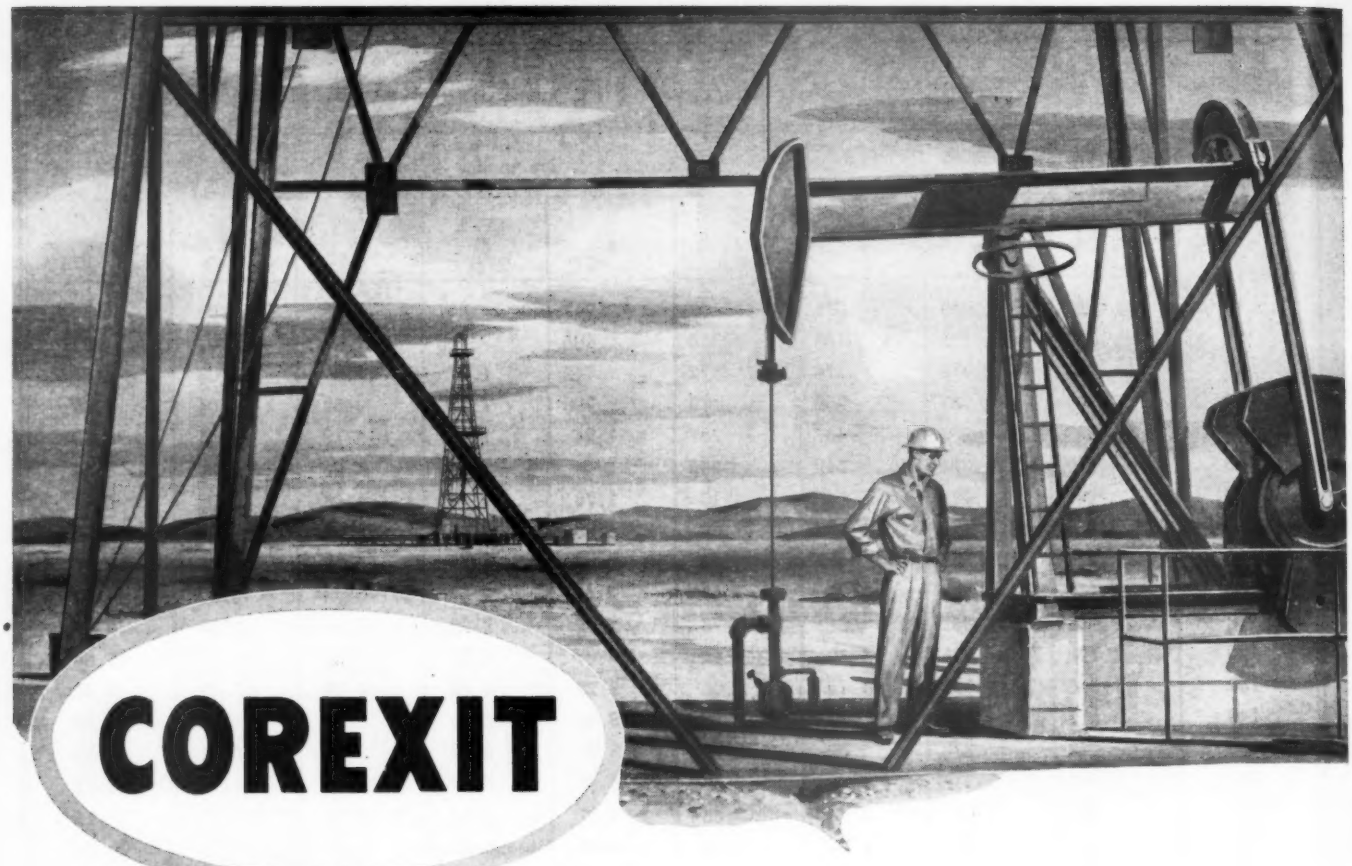
STORAGE CAPACITY OF PIPE LINES, BARRELS

Length of line	Nominal diameter of line, inches								
	2	2½	3	4	5	6	8	10	12
10 feet	.042	059	091	.157	.247	.357	.633	1.01	1.42
20	083	118	183	.315	.495	.715	1.27	2.02	2.84
30	.125	178	.274	.472	.742	1.07	1.90	3.03	4.26
40	.166	237	366	.630	.990	1.43	2.53	4.04	5.68
50	208	296	.457	.787	1.24	1.79	3.16	5.05	7.10
60	249	.355	549	.945	1.48	2.14	3.80	6.05	8.52
70	291	415	640	1.10	1.73	2.50	4.43	7.06	9.94
80	332	474	.732	1.26	1.98	2.86	5.06	8.07	11.36
90	374	533	.823	1.42	2.23	3.22	5.70	9.08	12.78
100	.415	.592	.914	1.57	2.47	3.57	6.33	10.09	14.20
110	457	.651	1.01	1.73	2.72	3.93	6.96	11.10	15.62
120	.498	711	1.10	1.89	2.97	4.29	7.59	12.11	17.04
130	540	.770	1.19	2.05	3.22	4.65	8 23	13 12	18.46
140	.581	.829	1.28	2.20	3.46	5.00	8.86	14.13	19.88
150	623	.888	1.37	2.36	3.71	5.36	9.49	15.14	21.30
160	.664	.948	1.46	2.52	3.96	5.72	10.12	16.15	22 72
170	.706	1.01	1.55	2.68	4.21	6.07	10.76	17 15	24.14
180	.747	1.07	1.65	2.83	4.45	6.43	11.39	18.16	25.56
190	.789	1.13	1.74	2.99	4.70	6.79	12.02	19.17	26.98
200	.830	1.18	1.83	3.15	4.95	7.15	12.66	20.18	28.40
300	1.25	1.78	2.74	4.72	7.42	10.72	18.98	30.27	42 60
400	1.66	2.37	3.66	6.30	9.90	14.29	25.31	40.36	56.80
500	2.08	2.96	4.57	7.87	12.37	17.87	31.64	50 46	71.00
1,000	4.15	5.92	9.14	15.75	24.74	35.73	63.28	100.91	141.99
1,500	6.23	8.88	13.72	23.62	37.12	53 60	94.92	151.37	212.99
2.000	8.30	11.84	18.29	31.49	49.49	71.47	126 56	201.82	283.99
2,500	10.38	14.80	22.86	39.36	61.86	89.33	158.20	252 28	354 98
3,000	12.45	17.77	27.43	47.24	74.23	107.20	189.84	302.73	425.98
3,500	14.53	20.73	32.00	55 11	86.61	125.07	221 48	353.19	496.98
4.000	16.60	23.69	36.58	62.98	98.98	142.93	253 12	403.64	567.97
4,500	18.68	26.65	41.15	70.86	111.35	160.80	284.76	454.10	638.97
5.000	20.75	29.61	45.72	78.73	123.72	178.67	316.40	504.55	709.97
1 mile	22	31	48	83	131	189	334	533	750
2	44	63	97	166	261	377	668	1,066	1,500
3	66	94	145	249	392	566	1,002	1,598	2,249
4	88	125	193	333	523	755	1,336	2,131	2,999
5	110	156	241	416	653	943	1,671	2,664	3,749
10			483	831	1,307	1,887	3,341	5,328	7,497
15			724	1,247	1,960	2,830	5,012	7.992	11,246
20			966	1,663	2,613	3,773	6,682	10.656	14,995
25				2,078	3,266	4,717	8,353	13.320	18,743
30				2,494	3,920	5,660	10,024	15,984	22,492
35				2,910	4,573	6,604	11,694	18,648	26,240
40				3,326	5,226	7,547	13,365	21,312	29,989
45				3,741	5,879	8,490	15,035	23,976	33,738
50				4,157	6,533	9,434	16,706	26,640	37,486
55				4,573	7,186	10,377	18,377	29,304	41,235
60				4,988	7,839	11,320	20,047	31,968	44.984
65				5,404	8,492	12,264	21,718	34,632	48.732



COREXIT

Reduces sucker rod failures

SAVES HUNDREDS OF DOLLARS

Corexit builds a protective coating

Corexit is a patented compound that gradually builds up a protective coating inside the tubing and on sucker rods in sour crude wells to prevent corrosion. Tests show that where corrosion has already started, Corexit is effective in checking further corrosion.

Combats hydrogen embrittlement

In sour crude wells, many sucker rod failures are caused by hydrogen embrittlement. Corexit coats corroded spots on old sucker rods and prevents the entrance of additional atomic hydrogen. On new sucker rods, Corexit combats hydrogen embrittlement. Write for further information today.

HUMBLE

HUMBLE OIL & REFINING COMPANY P. O. BOX 2180 • HOUSTON, TEXAS

XUM

CORRELATION INDEX[1] (C. I.) VALUES IN CRUDE-OIL ANALYSES[2]

Specific gravity, G, of fraction at 60°F/60°F	Fraction no.[3]	Constant for fraction[4]	Temperature limits of fraction, °C.	Average volumetric boiling point[5] of fraction, °K	Correlation index (C. I.) values — Specific gravity—third decimal place									
					0.000	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
0.650	2	309.9	50– 75	331	.....	.....	.....	.....	.....	0.8	0.9	1.3	1.8	2.3
0.660	2				2.7	3.2	3.7	4.2	4.6	5.1	5.6	6.1	6.5	7.0
0.670	2				7.5	8.0	8.4	8.9	9.4	9.8	10.	11.	11.	12.
.670	3	319.8	75–100	355	.....	.....	.....	.....	.....	.....	0.4	0.9	1.4	1.8
0.680	2				12.	13.	13.	14.	14.	15.	15.	16.	16.	17.
.680	3				2.3	2.8	3.3	3.7	4.2	4.7	5.2	5.6	6.1	6.6
0.690	2				17.	17.	18.	18.	19.	19.	20.	20.	21.	21.
.690	3				7.1	7.5	8.0	8.5	8.9	9.4	10.	10.	11.	11.
.690	4	328.8	100–125	380	.....	.....	.....	.....	.....	0.4	0.9	1.4	1.8	2.3
0.700	2				22.	22.	23.	23.	24.	24.	25.	25.	26.	26.
.700	3				12.	12.	13.	13.	14.	14.	15.	15.	16.	16.
.700	4				2.8	3.3	3.7	4.2	4.7	5.2	5.6	6.1	6.6	7.1
0.710	2				26.	27.	27.	28.	28.	29.	29.	30.	30.	31.
.710	3				17.	17.	18.	18.	18.	19.	19.	20.	20.	21.
.710	4				7.5	8.0	8.5	8.9	9.4	9.9	10.	11.	11.	12.
.710	5	336.4	125–150	404	.....	0.4	0.9	1.3	1.8	2.3	2.8	3.2	3.7	4.2
0.720	2													
.720	3				21.	22.	22.	23.	23.	24.	24.	25.	25.	26.
.720	4				12.	13.	13.	14.	14.	15.	15.	16.	16.	17.
.720	5				4.7	5.1	5.6	6.1	6.6	7.0	7.5	8.0	8.5	8.9
.720	6	343.2	150–175	428	.....	.....	.....	.....	.....	0.2	0.7	1.2	1.7	2.1
0.730	3				26.	27.	27.	27.	28.	28.	29.	29.	30.	30.
.730	4				17.	18.	18.	18.	19.	19.	20.	20.	21.	21.
.730	5				9.4	9.9	10.	11.	11.	12.	12.	13.	13.	14.
.730	6				2.6	3.1	3.5	4.0	4.5	5.0	5.4	5.9	6.4	6.9
.730	7	394.4	175–200	453	.....	.....	.....	.....	.....	.....	.....	.....	0.2	0.7
0.740	3				31.	31.	32.	32.	33.	33.	34.	34.	35.	35.
.740	4				22.	22.	23.	23.	24.	24.	25.	25.	26.	26.
.740	5				14.	15.	15.	16.	16.	17.	17.	18.	18.	18.
.740	6				7.3	7.8	8.3	8.8	9.2	9.7	10.	11.	11.	12.
.740	7				1.1	1.6	2.1	2.6	3.0	3.5	4.0	4.5	4.9	5.4
0.750	3				36.	36.	36.	37.	37.	38.	38.	39.	39.	40.
.750	4				27.	27.	27.	28.	28.	29.	29.	30.	30.	31.
.750	5				19.	19.	20.	20.	21.	21.	22.	22.	23.	23.
.750	6				12.	13.	13.	14.	14.	14.	15.	15.	16.	16.
.750	7				5.9	6.3	6.8	7.3	7.8	8.2	8.7	9.2	10.	10.
.750	8	355.0	200–225	478	0.3	0.7	1.2	1.7	2.2	2.6	3.1	3.6	4.1	4.5
0.760	3				40.	41.	41.	42.	42.	43.	43.	43.	44.	44.
.760	4				31.	32.	32.	33.	33.	34.	34.	35.	35.	36.
.760	5				24.	24.	25.	25.	26.	26.	27.	27.	27.	28.
.760	6				17.	17.	18.	18.	19.	19.	20.	20.	21.	21.
.760	7				11.	11.	12.	12.	13.	13.	14.	14.	14.	15.
.760	8				5.0	5.5	6.0	6.4	6.9	7.4	7.9	8.3	8.8	9.3
.760	9	360.3	225–250	504	.....	0.2	0.7	1.1	1.6	2.1	2.6	3.0	3.5	4.0
0.770	4				36.	36.	37.	37.	38.	38.	39.	39.	40.	40.
.770	5				28.	29.	29.	30.	30.	31.	31.	32.	32.	33.
.770	6				22.	22.	23.	23.	23.	24.	24.	25.	25.	26.
.770	7				15.	16.	16.	17.	17.	18.	18.	19.	19.	20.
.770	8				9.7	10.	11.	11.	12.	12.	13.	13.	14.	14.
.770	9				4.4	4.9	5.4	5.9	6.3	6.8	7.3	7.8	8.2	8.7
.770	10	365.0	250–275	530	.....	0.2	0.7	1.2	1.6	2.1	2.6	3.1	3.5	4.0
0.780	4				41.	41.	42.	42.	43.	43.	43.	44.	44.	45.
.780	5				33.	34.	34.	35.	35.	36.	36.	36.	37.	37.
.780	6				26.	27.	27.	28.	28.	29.	29.	30.	30.	31.
.780	7				.20	21.	21.	22.	22.	23.	23.	23.	24.	24.
0.780	8				15.	15.	15.	16.	16.	17.	17.	18.	18.	19.
.780	9				9.2	9.7	10.	11.	11.	12.	12.	13.	13.	13.
.780	10				4.5	5.0	5.4	5.9	6.4	6.9	7.3	7.8	8.3	8.7
.780	11	369.0	To 200[6]	554[7]	0.5	1.0	1.4	1.9	2.4	2.9	3.3	3.8	4.3	4.7
.780	12	372.8	200–225	579	.....	.....	.....	.....	.....	.....	.....	.....	0.5	0.9
.780														

[1]The correlation index is a number whose magnitude indicates certain characteristics of a crude-oil distillation fraction. If the fraction be from a paraffin-base crude oil, its index will be small; if from intermediate and naphthene-base crude oils the indexes will be increasingly larger.

[2]When analyses are made by the Bureau of Mines Hempel method.

[3]In the Hempel method, all hydrocarbon fractions are designated by number, based on boiling range, from 1 to 15, inclusive.

[4]The constant for each fraction represents the first and third terms (48640/K — 456.8) in the equation: C.I. = 48640/K + 473.7G — 456.8, in which C.I. is the correlation index, K is the average boiling point of the fraction in degrees Kelvin (degrees C. + 273), and G is the specific gravity of the fraction at 60°F./60°F.

[5]Uncorrected for emergent stem.

[6]Fractions 2 to 10 are at atmospheric pressure; fractions 11 to 15 are at 40 mm. pressure.

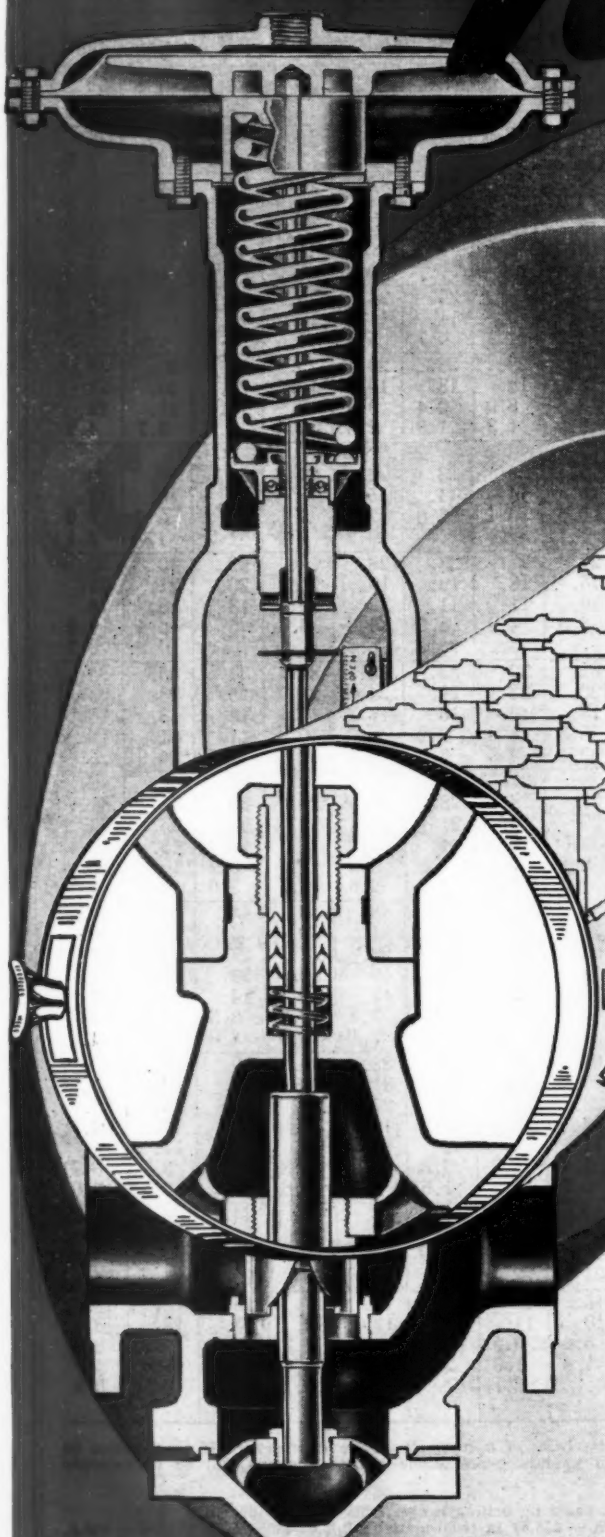
[7]Temperatures for fractions 11 to 15 are calculated at atmospheric pressure.

Table (with additions and rearrangement) is taken largely from *Correlation Index To Aid In Interpreting Crude-Oil Analyses* by Harold M. Smith, U. S. Bureau of Mines Technical Paper 610, published in 1940.

FISHER®

Teflon*

V-RING PACKING



. . . LEADING THE MARCH TO BETTER DIAPHRAGM MOTOR VALVE PERFORMANCE

Proved by many months of field service, Fisher Teflon V-Ring Packing features:

- *No gland leakage.*
- *Used on wide range of pressures without appreciable change in friction values.*
- *Elimination of maintenance and adjustment.*
- *No valve stem lubricators required.*
- *Chemically inert to all fluids up to 450° F.*

Fisher Teflon V-Ring Packing is now standard equipment on all Fisher Diaphragm Motor Valves.

Bulletin E-200 gives complete details.

*Teflon is the trade name of E. I. Du Pont de Nemours & Co.

FISHER GOVERNOR COMPANY

MARSHALLTOWN, IOWA

XUM

CORRELATION INDEX[1(a)] (C. I.) VALUES IN CRUDE-OIL ANALYSES[2]

Specific gravity, G, of fraction at 60°F/60°F	Fraction no.[3]	Constant for fraction[4]	Temperature limits of fraction, °C.	Average volumetric boiling point[5] of fraction, °K	Correlation index (C. I.) values — Specific gravity—third decimal place									
					0.000	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
0.790	5	336.4	125–150	404	38.	38.	39.	39.	40.	40.	41.	41.	42.	42.
.790	6	343.2	150–175	428	31.	32.	32.	32.	33.	33.	34.	34.	35.	35.
.790	7	394.4	175–200	453	25.	25.	26.	26.	27.	27.	28.	28.	29.	29.
.790	8	355.0	200–225	478	19.	20.	20.	21.	21.	22.	22.	23.	23.	24.
0.790	9	360.3	225–250	504	14.	14.	15.	15.	16.	16.	17.	17.	18.	18.
.790	10	365.0	250–275	530	9.2	9.7	10.	11.	11.	12.	12.	13.	13.	14.
.790	11	369.0	To 200[6]	554[7]	5.2	5.7	6.2	6.6	7.1	7.6	8.1	8.5	9.0	9.5
.790	12	372.8	200–225	579	1.4	1.9	2.4	2.8	3.3	3.8	4.3	4.7	5.2	5.7
.790	13	376.1	225–250	603						0.5	1.0	1.4	1.9	2.4
0.800	5				43.	43.	43.	44.	44.	45.	45.	46.	46.	47.
.800	6				36.	36.	37.	37.	38.	38.	39.	39.	40.	40.
.800	7				30.	30.	31.	31.	32.	32.	32.	33.	33.	34.
.800	8				24.	24.	25.	25.	26.	26.	27.	27.	28.	28.
.800	9				19.	19.	20.	20.	21.	21.	22.	22.	22.	23.
0.800	10				14.	14.	15.	15.	16.	16.	17.	17.	18.	18.
.800	11				10.	10.	11.	11.	12.	12.	13.	13.	14.	14.
.800	12				6.2	6.6	7.1	7.6	8.1	8.5	9.0	9.5	9.9	10.4
.800	13				2.9	3.3	3.8	4.3	4.8	5.2	5.7	6.2	6.6	7.1
.800	14	379.3	250–275	628		0.1	0.6	1.1	1.6	2.0	2.5	3.0	3.4	3.9
.800	15	382.3	275–300	653									0.4	0.9
0.810	6				41.	41.	41.	42.	42.	43.	43.	44.	44.	45.
.810	7				34.	35.	35.	36.	36.	37.	37.	38.	38.	39.
.810	8				29.	29.	30.	30.	31.	31.	32.	32.	33.	33.
.810	9				23.	24.	24.	25.	25.	26.	26.	27.	27.	28.
.810	10				19.	19.	20.	20.	21.	21.	22.	22.	23.	23.
0.810	11				15.	15.	16.	16.	17.	17.	18.	18.	19.	19.
.810	12				11.	11.	12.	12.	13.	13.	14.	14.	15.	15.
.810	13				7.6	8.1	8.5	9.0	9.5	10.0	10.4	10.9	11.4	11.9
.810	14				4.4	4.9	5.3	5.8	6.3	6.8	7.2	7.7	8.2	8.7
.810	15				1.4	1.9	2.3	2.8	3.3	3.8	4.2	4.7	5.2	5.7
0.820	6				45.	46.	46.	47.	47.	48.	48.	49.	49.	50.
.820	7				39.	40.	40.	41.	41.	41.	42.	42.	43.	43.
.820	8				33.	34.	34.	35.	35.	36.	36.	37.	37.	38.
.820	9				28.	29.	29.	30.	30.	31.	31.	31.	32.	32.
.820	10				23.	24.	24.	25.	25.	26.	26.	27.	27.	28.
0.820	11				19.	20.	20.	21.	21.	22.	22.	23.	23.	24.
.820	12				16.	16.	17.	17.	18.	18.	19.	19.	19.	20.
.820	13				12.	13.	13.	14.	14.	15.	15.	16.	16.	17.
.820	14				9.1	9.6	10.	11.	11.	11.	12.	12.	13.	13.
.820	15				6.1	6.6	7.1	7.6	8.0	8.5	9.0	9.4	9.9	10.
0.830	6				50.	50.	51.	51.	52.	52.	53.	53.	54.	54.
.830	7				44.	44.	45.	45.	46.	46.	47.	47.	48.	48.
.830	8				38.	39.	39.	40.	40.	41.	41.	42.	42.	42.
.830	9				33.	33.	34.	34.	35.	35.	36.	36.	37.	37.
.830	10				28.	29.	29.	30.	30.	31.	31.	32.	32.	32.
0.830	11				24.	25.	25.	26.	26.	27.	27.	28.	28.	28.
.830	12				20.	21.	21.	22.	22.	23.	23.	24.	24.	25.
.830	13				17.	18.	18.	19.	19.	19.	20.	20.	21.	21.
.830	14				14.	14.	15.	15.	16.	16.	17.	17.	18.	18.
.830	15				11.	11.	12.	12.	13.	13.	14.	14.	15.	15.
0.840	7				49.	49.	50.	50.	50.	51.	51.	52.	52.	53.
.840	8				43.	43.	44.	44.	45.	45.	46.	46.	47.	47.
.840	9				38.	38.	39.	39.	40.	40.	41.	41.	41.	42.
.840	10				33.	33.	34.	34.	35.	35.	36.	36.	37.	37.
0.840	11				29.	29.	30.	30.	31.	31.	32.	32.	33.	33.
.840	12				25.	26.	26.	27.	27.	28.	28.	28.	29.	29.
.840	13				22.	22.	23.	23.	24.	24.	25.	25.	26.	26.
.840	14				19.	19.	20.	20.	21.	21.	22.	22.	22.	23.
.840	15				16.	16.	17.	17.	18.	18.	19.	19.	19.	20.
0.850	7				53.	54.	54.	55.	55.	56.	56.	57.	57.	58.
.850	8				48.	48.	49.	49.	50.	50.	51.	51.	51.	52.
.850	9				42.	43.	43.	44.	44.	45.	45.	46.	46.	47.
.850	10				38.	38.	39.	39.	40.	40.	41.	41.	41.	42.
0.850	11				34.	34.	35.	35.	36.	36.	37.	37.	37.	38.
.850	12				30.	30.	31.	31.	32.	32.	33.	33.	34.	34.
.850	13				27.	27.	28.	28.	28.	29.	29.	30.	30.	31.
.850	14				23.	24.	24.	25.	25.	26.	26.	27.	27.	28.
.850	15				20.	21.	21.	22.	22.	23.	23.	24.	24.	25.

(a) For explanatory notes see sheet 1, P 721.02.

INDUSTRIAL STABILITY...

INDUSTRIAL STABILITY, the hall mark of the PETROLEUM INDUSTRY, is one of the salutary characteristics which has long been reflected in the Shand & Jurs Organization. For years there has been in evidence a steadiness of purpose in manufacturing only Quality Products—up to a standard, never down to a price. There has been a constancy of conviction that the design must be "right" before a product is placed in production; a firmness of resolution in thoroughly testing and proving equipment, before permitting it to be scattered to the far corners of the world. There has been a persistence in our belief that to maintain a position of leadership there must be a continuity of personnel, or men's minds will not long travel in the same direction. Consider the stability of the Shand & Jurs engineers who call at your offices. They are not recent college graduates, fired with ambition, fortified with a diploma, but lacking experience. The men who represent Shand & Jurs have been in our service an average of 15 years each—men who are experienced with your problems—trustworthy men in whom you can repose full confidence. If you want to be sure, when you begin an important project, that you will not have to educate several sales representatives, that the man you start out with will most likely still be on the job when it is completed, consult with the Shand & Jurs Engineer.

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XUM

CORRELATION INDEX[1(a)] (C. I.) VALUES IN CRUDE-OIL ANALYSES[2]

Specific gravity, G, of fraction at 60°F/60°F	Fraction no.[3]	Constant for fraction[4]	Temperature limits of fraction, °C.	Average volumetric boiling point[5] of fraction, °K	Correlation index (C. I.) values — Specific gravity—third decimal place									
					0.000	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
0.860	7	394.4	175–200	453	58.	58.	59.	59.	60.	60.	61.	61.	62.	62.
.860	8	355.0	200–225	478	52.	53.	53.	54.	54.	55.	55.	56.	56.	57.
.860	9	360.3	225–250	504	47.	48.	48.	49.	49.	50.	50.	50.	51.	51.
.860	10	365.0	250–275	530	42.	43.	43.	44.	44.	45.	45.	46.	46.	47.
0.860	11	369.0	To 200[6]	554[7]	38.	39.	39.	40.	40.	41.	41.	42.	42.	43.
.860	12	372.8	200–225	579	35.	35.	36.	36.	37.	37.	37.	38.	38.	39.
.860	13	376.1	225–250	603	31.	32.	32.	33.	33.	34.	34.	35.	35.	36.
.860	14	379.3	250–275	628	28.	29.	29.	30.	30.	31.	31.	31.	32.	32.
.860	15	382.3	275–300	653	25.	26.	26.	27.	27.	28.	28.	28.	29.	29.
0.870	8				57.	58.	58.	59.	59.	60.	60.	60.	61.	61.
.870	9				52.	52.	53.	53.	54.	54.	55.	55.	56.	56.
.870	10				47.	48.	48.	49.	49.	50.	50.	50.	51.	51.
.870	11				43.	44.	44.	45.	45.	46.	46.	46.	47.	47.
0.870	12				39.	40.	40.	41.	41.	42.	42.	43.	43.	44.
.870	13				36.	37.	37.	37.	38.	38.	39.	39.	40.	40.
.870	14				33.	33.	34.	34.	35.	35.	36.	36.	37.	37.
.870	15				30.	30.	31.	31.	32.	32.	33.	33.	34.	34.
0.880	8				62.	62.	63.	63.	64.	64.	65.	65.	66.	66.
.880	9				57.	57.	58.	58.	59.	59.	59.	60.	60.	61.
.880	10				52.	52.	53.	53.	54.	54.	55.	55.	56.	56.
.880	11				48.	48.	49.	49.	50.	50.	51.	51.	52.	52.
0.880	12				44.	45.	45.	46.	46.	46.	47.	47.	48.	48.
.880	13				41.	41.	42.	42.	43.	43.	44.	44.	45.	45.
.880	14				38.	38.	39.	39.	40.	40.	40.	41.	41.	42.
.880	15				35.	35.	36.	36.	37.	37.	37.	38.	38.	39.
0.890	8				67.	67.	68.	68.	69.	69.	69.	70.	70.	71.
.890	9				61.	62.	62.	63.	63.	64.	64.	65.	65.	66.
.890	10				57.	57.	58.	58.	59.	59.	59.	60.	60.	61.
.890	11				53.	53.	54.	54.	55.	55.	55.	56.	56.	57.
0.890	12				49.	49.	50.	50.	51.	51.	52.	52.	53.	53.
.890	13				46.	46.	46.	47.	47.	48.	48.	49.	49.	50.
.890	14				42.	43.	43.	44.	44.	45.	45.	46.	46.	47.
.890	15				39.	40.	40.	41.	41.	42.	42.	43.	43.	44.
0.900	10				61.	62.	62.	63.	63.	64.	64.	65.	65.	66.
.900	11				57.	58.	58.	59.	59.	60.	60.	61.	61.	62.
.900	12				54.	54.	55.	55.	55.	56.	56.	57.	57.	58.
.900	13				50.	51.	51.	52.	52.	53.	53.	54.	54.	55.
.900	14				47.	48.	48.	49.	49.	49.	50.	50.	51.	51.
.900	15				44.	45.	45.	46.	46.	46.	47.	47.	48.	48.
0.910	11				62.	63.	63.	64.	64.	64.	65.	65.	66.	66.
.910	12				58.	59.	59.	60.	60.	61.	61.	62.	62.	63.
.910	13				55.	55.	56.	56.	57.	57.	58.	58.	59.	59.
.910	14				52.	52.	53.	53.	54.	54.	55.	55.	56.	56.
.910	15				49.	49.	50.	50.	51.	51.	52.	52.	53.	53.
0.920	11				67.	67.	68.	68.	69.	69.	70.	70.	71.	71.
.920	12				63.	64.	64.	64.	65.	65.	66.	66.	67.	67.
.920	13				60.	60.	61.	61.	62.	62.	63.	63.	64.	64.
.920	14				57.	57.	58.	58.	58.	59.	59.	60.	60.	61.
.920	15				54.	54.	55.	55.	55.	56.	56.	57.	57.	58.
0.930	11				71.	72.	72.	73.	73.	74.	74.	75.	75.	76.
.930	12				68.	68.	69.	69.	70.	70.	71.	71.	72.	72.
.930	13				64.	65.	65.	66.	66.	67.	67.	68.	68.	69.
.930	14				61.	62.	62.	63.	63.	64.	64.	65.	65.	66.
.930	15				58.	59.	59.	60.	60.	61.	61.	62.	62.	63.
0.940	12				73.	73.	73.	74.	74.	75.	75.	76.	76.	77.
.940	13				69.	70.	70.	71.	71.	72.	72.	73.	73.	73.
.940	14				66.	67.	67.	67.	68.	68.	69.	69.	70.	70.
.940	15				63.	64.	64.	64.	65.	65.	66.	66.	67.	67.
0.950	12				77.	78.	78.	79.	79.	80.	80.	81.	81.	82.
.950	13				74.	74.	75.	75.	76.	76.	77.	77.	78.	78.
.950	14				71.	71.	72.	72.	73.	73.	74.	74.	75.	75.
.950	15				68.	68.	69.	69.	70.	70.	71.	71.	72.	72.
0.960	13				79.	79.	80.	80.	81.	81.	82.	82.	82.	83.
.960	14				76.	76.	76.	77.	77.	78.	78.	79.	79.	80.
.960	15				73.	73.	73.	74.	74.	75.	75.	76.	76.	77.
0.970	14				80.	81.	81.	82.	82.	83.	83.	84.	84.	85.
.970	15				77.	78.	78.	79.	79.	80.	80.	81.	81.	82.
0.980	14				85.	85.	86.	86.	87.	87.	88.	88.	89.	89.
.980	15				82.	82.	83.	83.	84.	84.	85.	85.	86.	86.
0.990	15				87.	87.	88.	88.	89.	89.	90.	90.	91.	91.

(a) For explanatory notes see sheet 1, P 721.02.

LAUGH with BARNEY

Bachelor: A guy who is foot-loose and fiancee free.

* * *

Edna: "You mustn't get discouraged. In this world there's a man for every girl and a girl for every man. You can't improve on an arrangement like that."

Pearl: "I don't want to improve on it. I just want to get in on it."

* * *

Grandmother was a diabetic patient, and, although put on a strict diet, she would not play the game, and was "cheating" all the time. After numerous violations, she was sent to the hospital.

Owing to the crowded condition of the hospital, the only available room was in the Maternity Ward. After she had been there a few days, her little granddaughter paid her a visit and was lolling in front of her grandmother's room when some visitors walked past. "What are you doing here, little girl?"

"I'm visiting my grandmother."

"Grandmother!" said one of the visitors in astonishment. "What is she doing here?"

"Oh," said the youngster, "she's been cheating again."

* * *

He took her auto-riding. She was a little angel and walked back. He took her boat-riding. She was a little angel and swam back. He took her airplane riding—the little devil!

The worst thing about history is that every time it repeats itself, prices go up.—Master Barber.

* * *

To keep within a budget, you have to let the rest of the world go buy.—Mine Workers Journal.

* * *

A chaperone is an old maid who never made the first team, but still wants to intercept a few passes.—Anon.

* * *

The owner of an electric blanket is the only person who can afford to be asleep at the switch.—Banking.

* * *

You can never tell how a girl will turn out until her folks turn in.

* * *

Then there were the three Chinese sisters:

Tu-Yung-Tu
No-Yen-Tu
Tu-Dum-Tu

* * *

When a woman says: "I'll be ready in a minute," you can be sure of one thing—she speaks English.

* * *

"Which would you rather give up—wine or women?"

"It depends on the vintage."

"It's oil, sir....LANE-WELLS on the job."

A Navy physician on a battleship in the Pacific recently received from his fiancee a snapshot taken on a beach and showing two couples smiling contentedly while his girl sat alone at one side, forlorn and lonely. The accompanying letter explained that this was how she was fretting away the time until he returned. At first the physician was delighted, displaying it proudly to several fellow officers. That night, however, after studying it a long time in silence, he turned to his roommate, "John," he said, "I wonder who took that picture?"

* * *

The little moron's watch had stopped ticking and he tried to find the trouble. Finally he took the back off it, went into the works and found a dead bug. "No wonder it doesn't work." he said, "the engineer's dead."

* * *

Men are peculiar, as women have long suspected. For instance, a man who hasn't kissed his wife for five years just shot a fellow who did.

* * *

An old Irishman collapsed in the street and a crowd soon gathered, all trying to help and each making suggestions. One, Maggie Riley, kept shouting, "Give the poor man whiskey," but little attention was paid to her.

Then the agonized voice of the Irishman rose above the din: "Will the lot of ye hold your tongues and let Maggie Riley speak?"

* * *

A young teacher was hired as a substitute for a friend who was taking a week off for a honeymoon. Later at a party, someone started to introduce her to the groom.

"Oh," he answered brightly, "I know Miss Jones very well indeed. She substituted for my wife on our honeymoon.

* * *

It seems that a former co-ed was in the habit of sending mash notes to her professors and signing them appropriately. Thus to her English prof, "Literally yours." To her math prof, "Mathematically yours." To her history prof, "Historically yours." And then she took anatomy.

* * *

When Pat and Mac registered they had to sign their names and nationality.

Pat signed: Irish—and proud of it.

Mac signed: Scotch—and fond of it.

* * *

Education, it seems, continues to shed its intellectual illumination over a dark world. The young ladies of a high school class, for instance, were recently required to write a book review of a popular novel. One young lady read the great work and reacted as follows:

"'Purple Passion' by Sarah Slushbucket is a modern novel of young love. The theme is the familiar 'Boy Meets Girl.' He doesn't care for her in the beginning, but he finds out that she's really marvelous in the middle, so he marries her in the end."

OIL and GAS TRADE NEWS

Frank Wheatley Pump Names New Officers at Board Meet

The thirty-seventh anniversary of the Frank Wheatley Pump and Valve Manufacturer was recognized by a meeting of the board of directors at that time. Several changes in management and

F. Wheatley, Sr.

F. Wheatley, Jr.

executive personnel were confirmed during the recent meeting.

Frank Wheatley, Sr., was made chairman of the firm. Frank Wheatley, Jr., was elevated from executive vice president to president. Charles Wheatley and Gus Baker, Jr., were added to the board and named vice presidents. Dan Lingo remains secretary-treasurer. William J. Gray, returning from a leave of absence, has been made director of material. Leo Mauching, after a short period of duty in outside sales, was named foundry superintendent. J. G. Burris, chief engineer, resigned.

In line with a newly inaugurated sales-distribution pattern for Wheatley, Ed Nolan was appointed field sales manager in charge of supply house distribution. Wheatley has named Jones and Laughlin, Franklin Supply Company, and the Bovaird Supply Company as distributors of their line of pumps and valves in the continental United States. The Charles Wheatley Company of Oklahoma, and the Wheatley Equipment and Supply Companies of Texas and Canada will continue to handle the line and act as consultants.

The Frank Wheatley board explained that the Charles Wheatley Company of Texas has changed its name to the Wheatley Equipment and Supply Company. This is the same name as that under which the Frank Wheatley Pump and Valve Company's Canadian subsidiary (WESCO) operates. Wheatley has, for the past three years, manufactured its line in Canada.

Winslow Opens New Offices

Establishment of new sales headquarters in Murray, Kentucky, and the transfer of key personnel from Oakland, California, to the southern city have been announced by Winslow Engineering Company, manufacturers of Winslow filters and elements.

Heading the group of men who moved east from the Pacific Coast was W. Ray Kern, the firm's general sales mangaer. He was accompanied by his assistant, W. B. "Bill" Walker, and division sales representative, Robert A. Pelusi. They will be joined in the near future by a second division sales representative who has not yet been appointed.

Kaiser Gets Safety Award

The National Safety Council presented to the Kaiser Steel plant in Fontana the "Award of Merit" in recognition of the plant's outstanding safety record during 1952. Joseph M. Kaplan, manager of the Los Angeles Chapter of the National Safety Council, made the presentation during luncheon ceremonies attended by 75 company and union officials and by safety committeemen from all production and maintenance departments.

Dodge Notes 75th Birthday

The Dodge Manufacturing Corporation has launched its fourth quarter-century of service to the industry following a series of community and plant events commemorating the 75th anniversary of the firm's founding.

A highlight of the observance was a civic testimonial luncheon at which a bronze plaque was presented, on behalf of the City of Mishawaka, by Mayor E. Spencer Walton to Joseph E. Otis, Jr., Dodge president. The engraved plaque, which followed adoption of a formal resolution by the City Council, reads: "Presented to the Dodge Manufacturing Corporation, gratefully commemorating three-quarters of a century of industrial progress and civic achievement in the City of Mishawaka, Indiana."

Another feature of the anniversary celebration was a plant Open House, two days later. More than 3200 guests, took guided tours of the Dodge plant.

McDonald Brothers Add New Department to Firm

Lloyd McDonald, partner of McDonald Brothers, Los Angeles construction firm, announced the addition of a design and engineering department that will be an integral part of their present construction service. Russel D. Koons, formerly with the Bechtel organization for 11 years, will spearhead this addition. George S. Ballew, formerly with Stone and Webster Engineering Corporation, is a well known specialist in petroleum process design. He will manage McDonald's service departments for the petroleum industry.

Gray Tool Names Agents

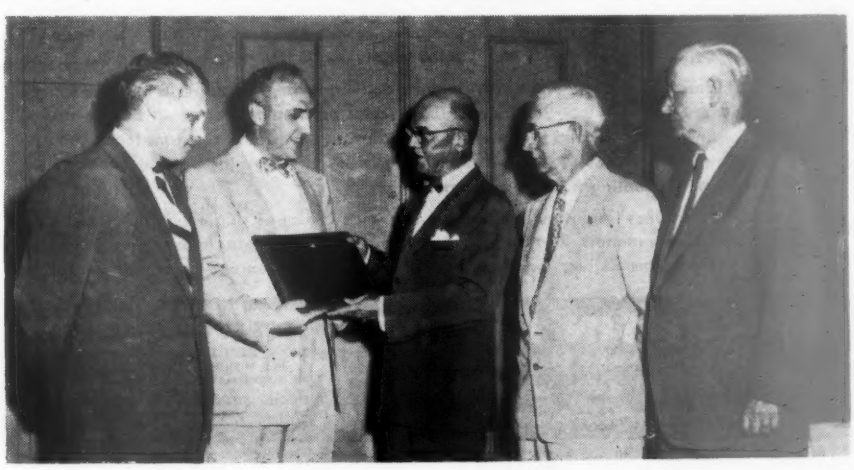
The Gray Tool Company of Houston announced the appointment of the Mid-Continent Supply Company as exclusive distributors for Gray Swivels and swivel parts in Canada. The company further announced that the Mid-Continent Supply Company is now a fully authorized distributor in the United States for Gray Swivels, and will maintain complete stocks of swivel parts.

Western Company Sets Up Ballinger, Texas, Store

The Western Company has opened a new field service station at Ballinger, Texas, it has been announced by H. E. Chiles, Jr., president. The new station will offer a complete line of Western's engineered well services.

Walter Beadle, vice president in charge of field operations for Western, has assigned J. A. Chaney station manager for pumping services and W. E. (Bill) Dennis to be manager of wire line services. J. W. (Jimmy) Wilkins will serve as sales engineer in Western's new service area. He previously was assigned to the Midland-Odessa area.

JOSEPH E. OTIS, JR., president of the Dodge Manufacturing Corporation (center) accepts a plaque given him by Mayor E. Spencer Walton, of Mishawaka, on the occasion of Dodge's 75th anniversary. Looking on are former Mishawaka mayors who were at the luncheon: Joe A. Brady; far right, Edward C. Went, second from right, Maston L. Petro.



XUM

Maloney-Crawford Opens Two New Branch Offices

New branch offices have been opened at Hobbs, New Mexico, and Healdton, Oklahoma, by the Maloney-Crawford Tank and Manufacutring Company, according to S. P. Wallace, president.

Personnel at Hobbs includes: H. H. Guthrie, branch manager; Bill Brock, field man, and T. E. Goodwin, in charge of the warehouse.

L. W. Moseley is branch manager, at Healdton, and G. W. Martin is in charge of the warehouse. Q. B. Johnson is field man.

Steel Service Plant Moves

Tube Distributors Company, Inc., has moved its general offices, stock and heavy equipment from its former site in Brooklyn, New York, to its modern, air-conditioned offices and warehouses recently completed in Garden City, Long Island, New York. The 45,000 sq ft warehouse was designed and landscaped to match the surrounding suburban architecture and Tube Distributors' operating requirements.

Graver Office Established

W. M. Broxham, vice president in charge of sales, Graver Tank and Manufacturing Company, Inc., has announced the opening of a new company office at Atlanta, Georgia. The new office is under the supervision of John R. O'Connor, district sales manager.

Bethlehem Supply Moves Gulf District Office

Bethlehem has moved its Louisiana Gulf district office from New Iberia to Harvey, Louisiana. J. B. Ellzey continues as district manager.

J. K. Davis, formerly in the New Orleans sales office, has been promoted to division machinery sales representative and now has headquarters at the Gulf Coast division office in Houston. He will be responsible for drilling barge and offshore problems in the division.

W. J. Vark has been promoted to machinery sales representative, replacing J. K. Davis. Vark, formerly field representative at the McAllen, Texas, store, is now at the district office at Harvey, Louisiana, and handles sales problems in the Louisiana Gulf district.

R. M. Dabney, formerly floorman at the Houston store, has replaced Vark as field representative at McAllen, Texas.

Chicago Pneumatic Buys Jacobs Manufacturing Stock

Chicago Pneumatic Tool Company announces that it has acquired the assets of The Jacobs Manufacturing Company of West Hartford, Connecticut. Manufacturing and sales operations will not be affected by the sale and will be carried on without change by a new wholly owned subsidiary of The Chicago Pneumatic Tool Company called The Jacobs Manufacturing Company.

California Is Site of Schlumberger Field Office

Fullerton, California, is the site of a new field office recently opened by the Schlumberger Well Surveying Corporation. The office is at 4129 West Commonwealth Avenue and will provide services for inland fields of the Los Angeles Basin.

Charles C. Arnold

The new office will be under the management of Charles C. Arnold. Arnold is a mechanical engineering graduate of the University of Illinois.

Hydro-Test Expands Service

Hydro-Test, Inc. of Long Beach expanded facilities for testing tubing by the recent appointment of two new representatives: Tube Testers, Inc., in Wichita Falls, Texas; and McAdams Pipe and Supply Company, in Great Bend, Kansas.

Tube Testers, Inc., operating from Wichita Falls, Texas, is headed by Paul Jamison and Clayton Hamm, formerly field representatives for Worth-Well Surveys out of Odessa.

The Hydro-Test method of testing tubing under hydraulic pressure as the tubing is made up and run back into the well is being introduced to Venezuelan fields by Superior Pipe Service C. A., a Venezuelan corporation. J. D. (Jack) Bryan, the company's president, remembered as a former drilling contractor from California, has his office at Aportado 220, El Tigre, Estado Anzoategui. Venezuela. This is the first Hydro-Test service to be offered in foreign fields.

New Southern Sales Office Set Up By Koppers Company

Establishment of a new sales office and appointment of a manager have been announced by C. H. Pottenger, sales manager of the chemical division of Koppers Company, Inc. Leo J. Diamond will be manager of the new Southern district sales office.

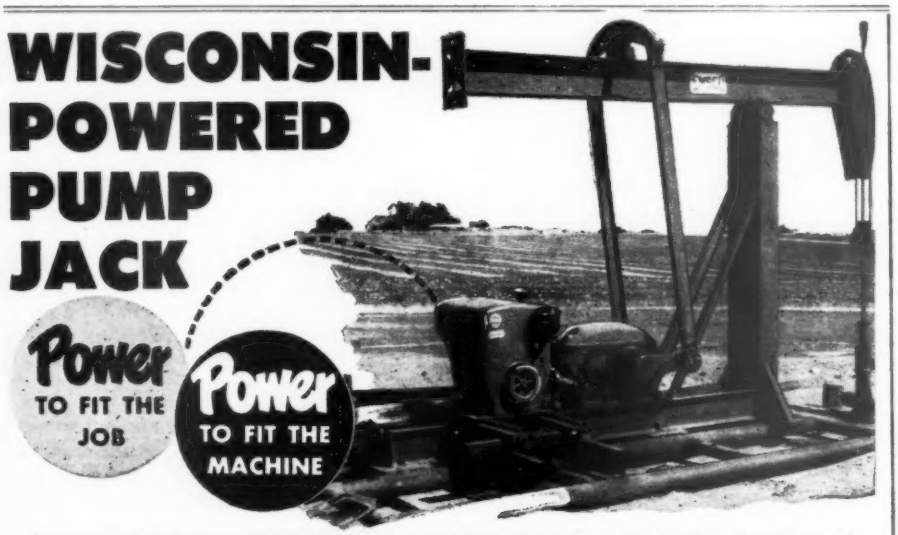
Emsco and D+B Consolidate Sales Offices in Dallas

Consolidation of the general sales offices of Emsco Manufacturing Company and its D+B Division in Dallas, Texas, is announced by William C. Kinder, vice president, recently appointed general sales manager.

William C. Kinder

The change will not only bring the direction of the sale of D+B production equipment and Emsco machinery products under one head, but also under one roof. Dallas offices are in Continental Building.

WISCONSIN-POWERED PUMP JACK



Power TO FIT THE JOB

Power TO FIT THE MACHINE

Down on a lonely Texas field this Emsco pumping jack pumps a *well*, with a 2-cylinder TF model Wisconsin Heavy-Duty Air-Cooled Engine supplying steady, day-in and day-out power.

Oil field equipment users see Wisconsin Engines delivering dependability under the toughest, most severe conditions . . . *continuous duty service* on many types of oil field pumping units. Wisconsins can go on and on, operating at constant speed and constant load, because of such construction features as thrust-absorbing tapered roller bearings at both ends of the shaft, fool-proof air-cooling and rugged construction.

But there's also another important advantage. The wide choice of single-cylinder, 2-cylinder and V-type 4-cylinder models, 3 to 36 hp., *always* permits the user to choose the *right* engine for the job. Wisconsins deliver *most* engine service with *least* engine wear and servicing.

WISCONSIN MOTOR Corporation
MILWAUKEE 46, WISCONSIN
World's Largest Builders of Heavy-Duty Air-Cooled Engines

WRITE TO HARLEY SALES CO.
619 S. MAIN STREET, TULSA, OKLAHOMA
M & M BUILDING, HOUSTON, TEXAS
505 SOUTH MAIN ST., WICHITA, KANSAS
OIL FIELD DISTRIBUTORS FOR WISCONSIN ENGINES AND ALL TYPES OF UTILITY UNITS.

TRADE PERSONALS

LeRoy Keane, director of sales, and **Harry V. Chase,** director of operations of Hercules Powder Company's Explosives Department, have been named assistant general managers of the department. Keane has been director of sales for the department since 1945, and has been associated with Hercules since 1918. Chase, who has completed 40 years of service with Hercules has held numerous supervisory posts in the company's commercial explosives plants. He joined Hercules as a chemist in 1913.

Brooks M. Dyer has been appointed as assistant director of sales for Columbia-Southern Chemical Corporation. Associated since 1943 with Columbia-Southern, a wholly-owned subsidiary of Pittsburgh Plate Glass Company, Dyer previously served as district sales manager at St. Louis and as assistant district sales manager at Philadelphia. **William Carpenter,** sales representative for Columbia-Southern at St. Louis has been appointed acting district sales manager at St. Louis.

Wilfred Gains has been named as assistant to W. E. Kelly, vice president in charge of engineering, Catalytic Construction Company. Gains was graduated from McMaster University and for 12 years he was associated with the Chemical Construction Corporation. More recently he was with the Vulcan Copper and Supply Company.

John H. Caldwell has recently joined the S. D. Day Company as sales engineer. He attended VMI, and Iowa State Teachers College and later was employed by Glen Martin Aircraft as corrosion engineer. Caldwell will devote his work to the Pittsburgh Coke and Chemical Division of "cold" coatings and their applications for industry on the Gulf Coast.

Edward H. Frederick has been recently appointed assistant general manager of Dynamatic Corporation, a subsidiary of Eaton Manufacturing Company. Frederick joined Dynamatic Corporation in 1949, as chief application engineer, the position he has held until his present promotion. He was previously associated with Allis-Chalmers Manufacturing Company.

Harold E. Huber has been named as a member of the technical sales department of The Girdler Corporation's votator division. A graduate of the University of Kentucky, Huber joined Girdler in 1943.

Ed Reif has been named Midland district sales manager for Black, Sivalls & Bryson, Inc. Reif has been with BS&B for the past 11 years. During that time, he has served BS&B as salesman, and branch manager at Casper. In his new capacity, Reif has supervision of sales and service activities of the oilfield division in the Midland sales district.

O. C. Sloan has been named West Texas representative for Beaumont Iron Works Company. His headquarters will be in Odessa. Sloan has been active in oilfield sales and service in West Texas and New Mexico for the last six and a half years. He was formerly with Wilson Supply Company in Monahans, Texas, and Texas Iron Works in Odessa.

O. C. Sloan

John F. Maher, president of Oil Center Tool Company, has recently completed an extensive tour of West Texas, New Mexico, the Rocky Mountain area, the Williston Basin, and Canada. He was accompanied by **Rex Galloup,** O-C-T sales manager. During the trip Maher and Galloup visited field offices to introduce the new O-C-T "C-20" casing head for use on medium depth wells and looked over new developments.

Ray R. Wagner has been appointed assistant district manager for Dowell at Oklahoma City. He will be responsible for all maintenance, safety, employee relations, and purchasing. Wagner holds an engineering degree from Kansas University.

Lee W. Hanson, formerly with Shell Petroleum Company, has joined the liquefied gas products division of the A. O. Smith Corporation as the sales representative covering south and central Texas out of Houston. Hanson was with the LPG marketing division of Shell for the past eight years.

R. H. Coe

R. W. Smith

L. L. Garren

L. E. Ash

E. J. Blackburn

O. C. Littlefield

Russell H. Coe has been appointed sales representative for the Kerotest Manufacturing Company in the Northeast section of the U. S. Coe will handle sales of Kerotest valves and fittings to petroleum transmission and refining companies, and to industrial firms in the area.

Coe has served as test engineer in the Indiana Harbor Plant of Youngstown Sheet and Tube Company, and as a sales engineer for that firm in seven Midwestern states.

Robert W. Smith has been appointed as Eastern division sales manager for McCullough Tool Company. He joined McCullough Tool Company in the same year as a field operator, later transferring to the sales department. In 1950, Smith was appointed Eastern division public relations director, a position he has held until his new appointment as sales manager.

L. L. (Red) Garren has been named manager of the Baash-Ross Tool Company's manufacturing plant now nearing completion in Canton, Ohio. Garren brings to his new position an extensive background in oil industry "know-how," having been reared in the industry as the son of an oilman. After a stretch in the armed forces, Garren attended the University of Oklahoma. He was formerly district manager of the Baash-Ross West Texas-New Mexico operations with headquarters in Odessa.

L. E. Ash has been named general construction superintendent of the refinery division of Macco Corporation. Ash, a native of West Virginia, comes to Macco with wide experience in the oil and chemical construction fields. For the last 6 years he has been with the Foster Wheeler Corporation.

E. J. Blackburn, formerly district manager of the Corpus Christi area for Sperry-Sun Well Surveying Company, has been transferred to Houston and is now manager of the Houston district. **O. C. Littlefield,** formerly sales engineer in Houston has been promoted to district manager of the Corpus Christi area with offices at 319 Westchester Drive, Corpus Christi, Texas.

Trade Personals

Karl L. Elliott has been named as president of the Acme Fisher Tool Company. Elliott has been connected with Acme since 1919, and has been vice president of sales in recent years.

Walter P. McKain has been selected as vice president of operations. McKain, son of the founder of Acme who began this business in 1900, has been chief engineer of the company since 1936, and in recent years has also been general superintendent.

Herschel C. Battin has been selected as treasurer and assistant treasurer of the parent Stardrill-Keystone Company. Battin has been in charge of Acme's accounting department since 1951. **Lewis M. Ludlow**, who has been president of Acme since 1918, is retiring from the active management of Acme at the end of July.

Robert R. McCartney has been named eastern division manager and director of export operations for Clark Bros. Company, Division of Dresser Operations, Inc. In his new position, McCartney will coordinate activities of the New York, Boston, Washington, and the new Philadelphia offices, in addition to serving as director of export operations for Clark.

Robert J. Spears has been named district manager of the New York office, succeeding McCartney. Spears joined Clark Bros. in 1938.

L. E. Ferguson

R. M. Farrell

Laurence E. Ferguson has been appointed sales manager for the Oklahoma-Kansas territory for Industrial Supply Company of Texas, Wichita Falls, Texas. He formerly was sales manager of the Wheland Company, and most recently was with the Iverson Supply Company.

Robert M. Farrell has been named Houston city salesman and representative for Oil Center Tool Company. Farrell is a former salesman for Oteco and has worked for major servicing companies, including Halliburton and Schlumberger. He attended Kansas State College.

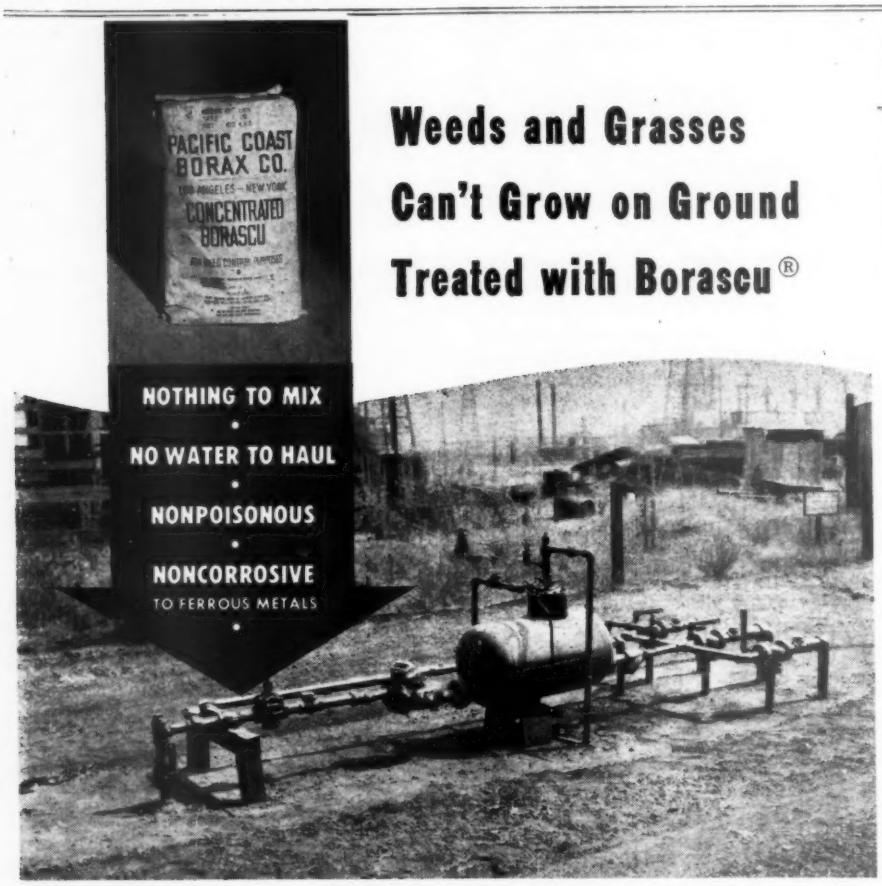
Harry Knecht, assistant mechanical plant engineer at the Consolidated Edison Company, has been elected chairman of the executive committee of the Metropolitan Section of The American Society of Mechanical Engineers. Other officers elected at a meeting on June 18 are **Allen T. Kniffen,** project engineer at the Air Reduction Company, secretary; **Henry J. Scagnelli,** engineer at the Ward Leonard Electric Company, treasurer; and **Miss Muriel O. England,** who was re-elected assistant secretary-treasurer.

V. Weaver Smith, vice president of The Lummus Company, was made a Fellow in the society. The award, for outstanding contributions in the mechanical engineering field, was presented by **Henry R. Kessler,** vice president of the society and manager of Republic Flow Meters Company.

John E. Bourdeau has been named division field engineer for the Reed Roller Bit Company and is now responsible for company field engineering activities in the West Texas area. Bourdeau is a graduate of the University of Texas. He has been with Reed's engineering department since 1947. Replaced in the West Texas and New Mexico area by Bourdeau, **Sterling Marshall** returned to Houston headquarters to assume the duties of product engineer for Reed.

Denver F. Wofford has been appointed manager of the Oklahoma sales division of Reed Roller Bit, replacing the late **E. A. Miller.**

Merle G. Decker has joined the sales force of Spang and Company. Decker has been with the Ohio Fuel Gas Company for 15 years. He comes to Spang and Company from the Acme Fishing Tool Company.



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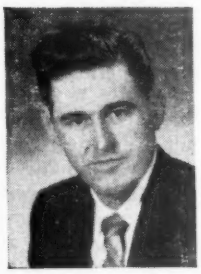
J. T. Clements, Fluid Packed Pump Company, formerly of Houston has been promoted to division manager for the entire Rocky Mountain and Canadian Territories — operating out of Casper, Wyoming. **Verlan Lewis** takes Clements place in Houston. **Ledford Smith** formerly district representative at Wichita

J. T. Clements

L. Smith

D. H. Vandenburg



H. Palmour

Falls has been promoted to district manager of all of North Texas. **Bill Duke** has been added to the company's Kansas force and is stationed at Plainsville, Kansas. **J. A. St. John,** formerly of Bay Petroleum Company and **C. H. Emerick** from California have been added to the West Texas sales staff. They will work out of Odessa. **George Nugent** has joined the Gulf Coast division with headquarters at Freer, Texas.

In keeping with the company's program of field training assistant plant managers, **Gordon Satterla** has returned to the company's plant at Los Nietos after 18 months of sales work and **D. H. Vandenburg,** assistant plant manager, joined the sales force at Odessa. **Harold Palmour,** formerly division manager in Shreveport, Louisiana, has been transferred to Fort Worth to supervise operation of the Oilmaster Rod weight compensator, dual zone production tool, etc.

W. V. Rathbone was elected first vice president with general supervision over sales, engineering, and purchasing activities of The Parkersburg Rig and Reel Company. His headquarters are being moved from Parkersburg, West Virginia, to Houston, Texas. He will take up his residence there in the late summer. Rathbone joined Parkersburg as vice president in 1948. He was previously associated with The Standard Oil Company of New Jersey as sales manager of the Enjay Company, an affiliate.

A. G. Evans-Lombe was elected vice president and general sales manager. He will continue to make his headquarters in Fort Worth, Texas, where he has resided and maintained his office since 1950.

J. D. Lowd who has been serving as assistant general manager at Houston, Texas, in connection with pressure vessel operations has been appointed western sales manager and transferred to Fort Worth. A graduate of Worcester Polytechnic Institute, Lowd joined Parkersburg in 1940.

J. Q. Callaway who has been serving as assistant to vice president, Evans-Lombe, was appointed eastern and export sales manager. He will continue to make his headquarters in Parkersburg.

W. H. Fitzer has been transferred from the Gulf Coast division office at Houston to New York and appointed assistant export sales manager. He joined Parkersburg as a sales engineer in 1947.

C. P. MacDonald, who has been in New York as export sales manager has been appointed assistant to the president and transferred to Parkersburg, West Virginia. A graduate of Virginia Military Institute, MacDonald joined Parkersburg in 1934.

In the manufacturing division, **G. E. Oller,** who has been serving as assistant general manager, has been appointed Eastern works manager in charge of the plant at Parkersburg and the foundry at Pomeroy, Ohio. Oller is a graduate of LeHigh University and has been with the company since 1930.

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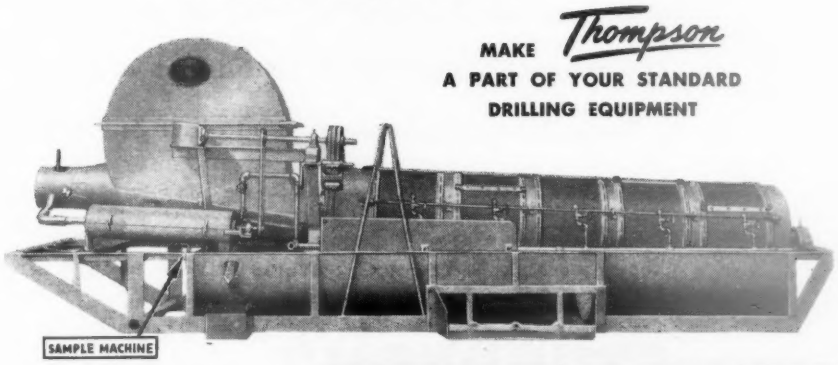

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Trade Personals

E. J. Byrnes, Jr., has been appointed assistant general manager of sales, eastern division, of The Colorado Fuel and Iron Corporation. In 1925, prior to the merger with CF&I, Byrnes joined the then Wickwire Spencer Steel Company. With his appointment as assistant general manager of sales of CF&I's eastern division, Byrnes will be situated at the executive offices of the corporation in New York City.

James E. Keffer has been named credit representative for The Continental Supply Company, Ltd., in Calgary, Alberta, Canada. Keffer joined Continental in 1946, and has served as branch store manager at McCamey, Texas, and at San Angelo, Texas, his last position before taking his new job. He attended Texas Technological College at Lubbock, Texas.

Wenzel A. Lindfors and **Carl G. Link** have been named to regional sales manager posts for New York Belting and Packing Company. Link will handle the Great Lakes region including the heavily industrialized Chicago, Pittsburgh, and Detroit areas; Lindfors will supervise sales in the rest of the country.

At the same time, **Wilbur E. Combs** was appointed merchandise manager and **Harry H. Raber** sales operating manger, both of whom will have headquarters at Passaic, New Jersey.

B. G. Price

V. R. Wittich

B. G. Price has been named vice president, engineering and research, for Tuboscope Company. Price joined Tuboscope in 1938, serving in field operations in Texas, Kansas, Illinois, Oklahoma, and South America until 1947. Upon his return to Houston he assumed the position of equipment engineer and later took charge of Tuboscope's fleet and equipment maintenance, design and construction.

Val. R. Wittich has been named exclusive export representative for Ben F. Kelley Company, Inc., Tulsa, Oklahoma. The Tulsa concern manufacturers KelCo air operated power slips, tubing tongs, breakout and spinning line catheads. Val R. Wittich organization will represent Ben F. Kelley Company, Inc., and KelCo products in all international markets except Canada and Mexico.

J. D. Grace has been appointed manager of the screen department, crusher division at Nordberg Manufacturing Company. Grace's former duties as manager of the advertising and sales department have been assumed by R. E. Schulz, manager advertising and sales department.

A. J. Herrmann has been named as vice president in charge of sales and secretary of the American Cast Iron Pipe Company. He succeeded **Lester Long**, who retired on July 12, after 38 years' continuous service with the company. He also will serve on the board of directors of the company and on the board of management. Herrmann has served as assistant general sales manager of American Cast Iron Pipe since 1952.

J. W. MacKay has been named as assistant general sales manager of American Cast Iron. MacKay has been employed in the Southern sales department of the American Cast Iron Pipe since the early part of 1951, having served as assistant Southern sales manager since 1952.

A. P. Kramer has been named as sales and service manager of Cleaner Pipelines Company. For the past five years Kramer was associated with the Great Lakes Pipe Line Company and for the last three years was the company's general superintendent in charge of the operating department. Prior to that he was sales and service representative for American Locomotive Company.

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STURDYBILT HOUSES COMPLY WITH COMMERCIAL STANDARD CS125 OF THE NATIONAL BUREAU OF STANDARDS FOR PREFABRICATED HOMES

BOOKS

High-Speed Diesel Engines, *P. M. Heldt. P. M. Heldt, Nyack, New York. $7.00. Pages, 472.*

This well known standard work on the compression-ignition engine cycles is just issued recently in its seventh edition, which shows a number of changes and additions as well as a few omissions. The chapter on two-cycle engines has been expanded especially by addition of certain charts having to do with shaking forces and rocking couples. Two chapters have been omitted, that on "Aircraft Engines," as diesel aircraft engines are no longer made; and on "Miscellaneous Types of Oil Engines," as the spark-ignition oil engine has passed out of the picture with the improvements of the high-speed, automotive diesel which has reached its present state of excellence.

The chapter on thermodynamics of these cycles has been augmented and expanded. Some new governing devices have been discussed that did not appear in the earlier editions. Although only about a dozen pages is devoted to it, a new chapter on "Gas Turbines" outlines the salient points in that important prime mover. The introduction of the Brown-Boveri (Swiss) turbine, as applied especially to locomotive powerplants is discussed and the principles of design and operation are explained along with the economic aspects. Significant is the statement quoted from J. T. Retaliata of Allis-Chalmers that at 2500 hp and below the turbine will not compete with the diesel, and that at outputs of 5000-20,000 hp the turbine will have a field all its own.

Drilling and Production Practice, API, 1952. *Published by The American Petroleum Institute, 300 Corrigan Tower Building, Dallas 1, Texas. Price, $5.00. Pages, 399.*

This 400 page, cloth bound volume contains 29 papers selected from all those presented at the district and annual meetings of the Division of Production of the American Petroleum Institute. Also printed is a complete bibliography of all papers presented during the year at the above meetings. Articles covering rig equipment, bits, drill fluids, cementing, and coring appear in the drilling practice section. The producing practices section covers, among other things, reservoir performance, secondary recovery, surface and subsurface equipment, etc.

Petroleum in the Western Hemisphere, *by the Western Hemisphere Oil Study Committee of the Independent Petroleum Association of America, 1437 South Boulder, Tulsa, Oklahoma. Pages, 183.*

This book is the report of a committee of experts in the petroleum field and provides a comprehensive analysis of future availability of petroleum in the Western Hemisphere through 1960. It also establishes a formula for predicting future conditions in the industry as related to production, demand, drilling, imports, reserves, and productive capacity.

Also included are comprehensive reports on vital trends in and industry, and government policies and laws, etc.

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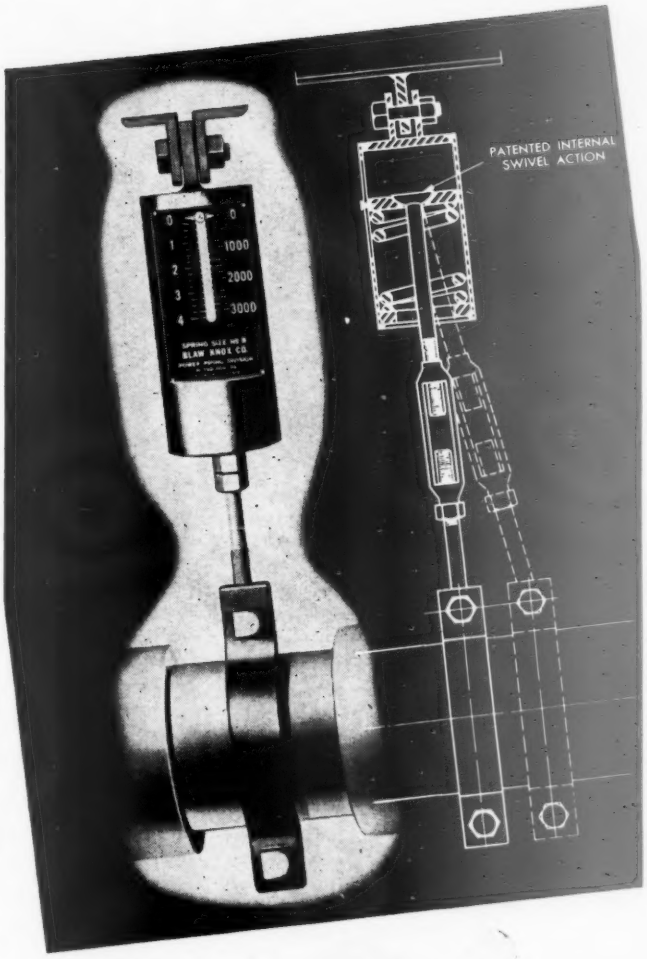

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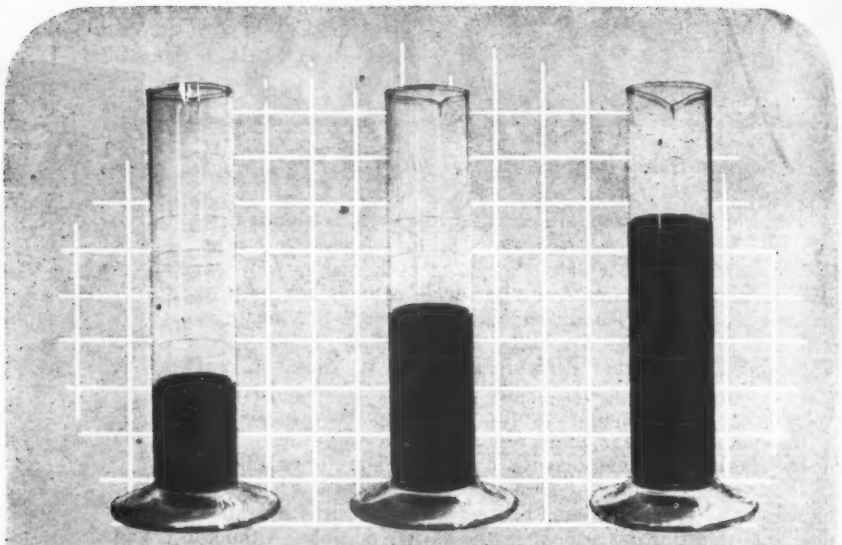
How Visco Quality CUTS YOUR EMULSION-BREAKER COSTS



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In each instance, Visco Class I is the highest-priced chemical—but the lowest in cost per barrel of dry oil!

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New Machinery and Supplies

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Circle corresponding letter or letters on reply card

(A) BLEEDER VALVE

A new idea in bleeder valves, the Greer-Lane valve, is announced by Greer Hydraulics, Inc. Designed for both hydraulic and penumatic lines of any size or pressure, this semi-automatic bleeder valve is a spring-loaded rotary type using a channeled, knife-edged cap that uncovers the bleed port wtih a twist of the external head.

Circle letter (A) on reply card.

(B) WELD-BACKING COMPOUND

A silicone weld-backing compound recently developed by the General Electric Company is now available from G-E welding distributors. The new compound permits greater welding flexibility by effectively promoting uniform penetration and eliminating the harmful effects of air on the underside of welds. It is well suited to applications in which the underside of the joint is difficult or completely impossible to reach for cleaning.

Circle letter (B) on reply card.

(C) WELDING MACHINE

Leader Welding and Manufacturing Company has announced development of a new automatic welding machine. This new unit, called the Model 650 Leader automatic welding machine, is built for heavy use. It is tailored to the needs of the industry and features an all new consolidated finger tip control panel; dual, adjustable, spring-braked rod-reel holders; motorized (20-1 ratio), acme-powered, 8-ft cross arm with side beam carriage, etc.

Circle letter (C) on reply card.

(D) PARTS WASHER

Quick, automatic cleaning of small parts, complete assemblies and tools is made possible by a new air-powered washer now being produced by Kelite Products, Inc. Cleaning of small parts or complete assemblies is achieved by the action of an oscillating turntable which is submerged in a cleaning solution. Parts to be cleaned are placed in a specially designed perforated basket that rides on the turntable; complete assemblies are placed directly on the turntable. Speed of Kelite automatic parts washer may be varied from 0 to 240 oscillations per minute, the company reports.

Circle letter (D) on reply card.

(E) CALCULATORS

A heat exchanger calculator for use in the selection of shell-and-tube type heat exchangers manufactured by the Young Radiator Company is now available upon request. Designed like a slide rule, the handy 2-color calculator provides all necessary data and simplifies Young Heat Exchanger selection. Essentially, the calculator is used to determine the square feet of surface necessary to transfer a given amount of heat between oil or water on the shell side, and water on the tube side.

Circle letter (E) on reply card.

(F) GEAR PULLERS

A new line of gear and wheel pullers has been announced by J. H. Williams and Company.

Jaws and blocks in the pullers are forged from selected steel and heat-treated for extra strength and safety. Jaw clips are self adjusting. Forcing screws are made of high quality alloy steel and heat-treated. New "unified" thread on screws and blocks is the latest development in screw thread design.

Circle letter (F) on reply card.

(G) BUTANE-PROPANE HOSE

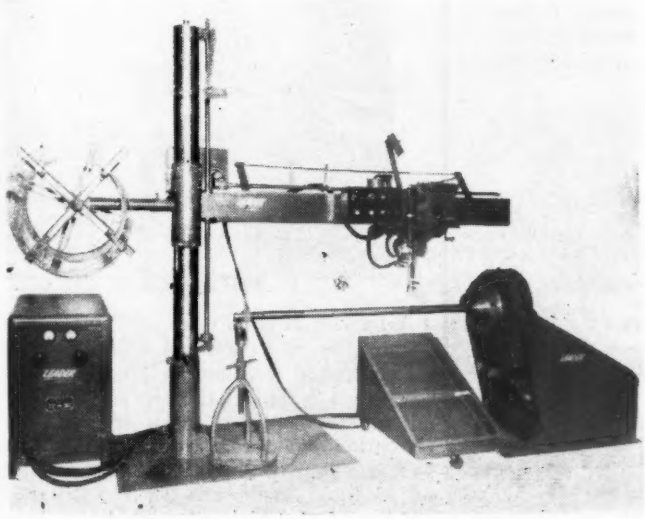
Ironsides butane-propane hose, a new type of butane hose combining layers of horizontally braided steel wire and rayon cord reinforcement, has been announced by Quaker Rubber Corporation, Division of H. K. Porter Company, Inc. Specially developed for the handling of liquefied petroleum gases, this hose features a non-porous and oil resistant rubber tube and strong reinforcement.

Circle letter (G) on reply card.

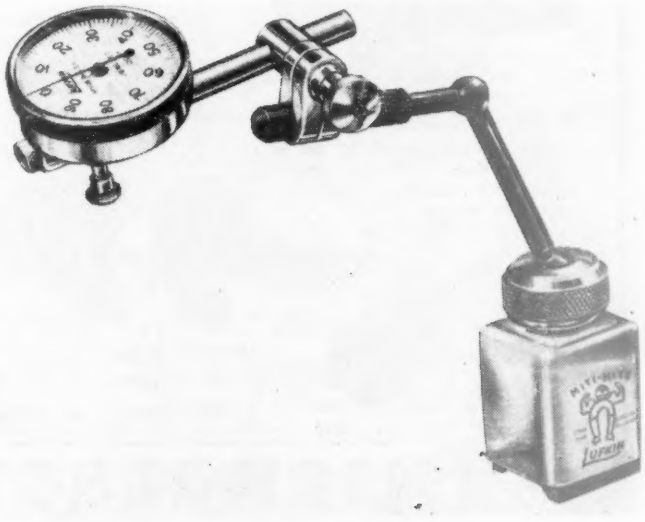
(H) INDICATOR HOLDERS

New Lufkin Rule Company "Miti-Mite" magnetic base indicator holders are now available. These magnetic base indicator holders eliminate cumbersome haphazard clamping—speed up the job and give greater accuracy. Indicator holder can be placed against any round or flat iron or steel surface—powerful permanent magnet attaches instantly.

Circle letter (H) on reply card.



LEADER WELDING AUTOMATIC WELDING MACHINE



MAGNETIC BASE INDICATOR HOLDERS

HAMER RIGID-TYPE line blind valves installed by Union Oil Company during recent modernization of the main pump house manifold at its Wilmington refinery.

(I) DITCHING MACHINE

A new model truck-mounted Earth-ripper ditching machine developed by Owen-Reuthers Manufacturing Company features a jack-knife boom that is raised and lowered hydraulically. The new design greatly reduces the head room of the machine, permitting it to travel beneath any underpass or other obstacle that provides clearance for the truck. The new boom also permits extending the bucket line at an angle behind the machine.

Circle letter (I) on reply card.

(J) PIPE FITTINGS

Carlon Products Corporation announced availability of a new reducer insert tee fitting in which the side outlet is one standard pipe size smaller than the run. This new fitting is available in run size up to two inches. The new reducer tee facilitates installation of step-down laterals. These new fittings are molded from a single piece of thermoplastic material and are guaranteed against rot, rust, and electrolytic corrosion, the company reported.

Circle letter (J) on reply card.

(K) LINE BLIND VALVE

A new 5-bolt, 18-in. line blind valve, specifically designed to fulfill growing demands by industry for a line blind valve that will accommodate larger pipe lines has been placed on the market by the Hamer Oil Tool Company. The new line blind has an ASA rating of 150 lb for working pressures up to 230 lb. It provides either a full-diameter, smooth, round opening, or a permanent, leak-proof shut-off.

Circle letter (K) on reply card.

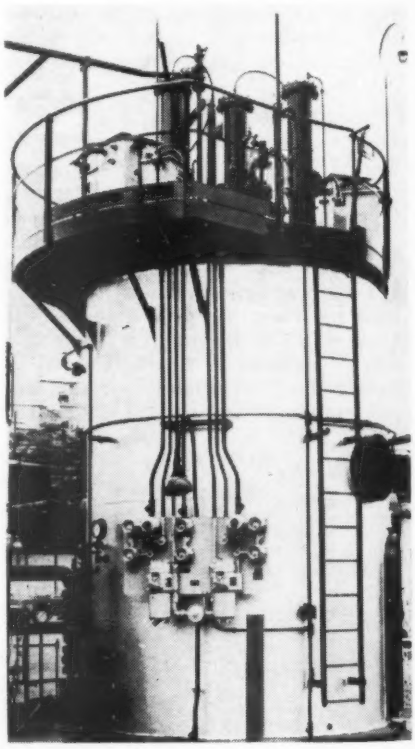
(L) PNEUMATIC CONTROL

A new low-unit-cost indicating pneumatic control thermometer has been introduced by the industrial division of Minneapolis-Honeywell Regulator Company. The new controller is available either with direct or reverse-acting "on-off" or limited throttler control units. Actuation is provided by standard vapor or mercury-filled thermal systems. The instrument, 11 in. by 11 in. by 4 in., is housed in a black die-cast aluminum case with a black phenolic cover.

Circle letter (L) on reply card.

(M) ELECTRIC LUBE OIL PROCESS

The Petreco division of the Petrolite Corporation has announced the development and commercial application of an electric process for acid-treating lube oil and similar stocks. The process, designated at the Petreco electric lube oil process, is a continuous, automatically-controlled treating method, and is designed to replace the conventional batch agitator method for acid treating lubricating oil stocks. Petreco processing, being automatic and continuous, replaces manual "art" and "skill" with engineered precision control.

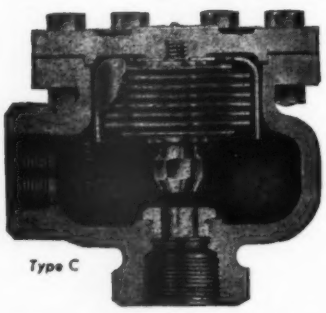


Circle letter (M) on reply card.

Nicholson Steam Traps

CUT KETTLE TIME 30%

for Leading Processor



Type C

Records of a recent installation of Nicholson steam traps, by a large processor, show they cut kettle time 30%. For example, one operation was shortened from 65 to 45 minutes. Nicholson units keep equipment full of live steam because: 1) they operate on lowest temperature differential; 2) have 2 to 6 times average drainage capacity; 3) maximum air-venting capacity. See why leading plants are increasingly standardizing on Nicholsons.

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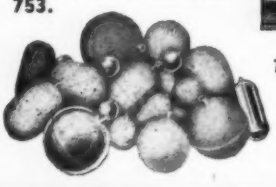

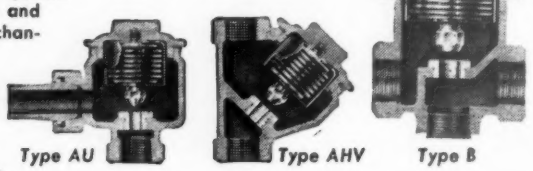

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5 TYPES for Every Use — process, heat, power. Size ¼" to 2"; press. to 250 lbs. **BULLETIN 853.**

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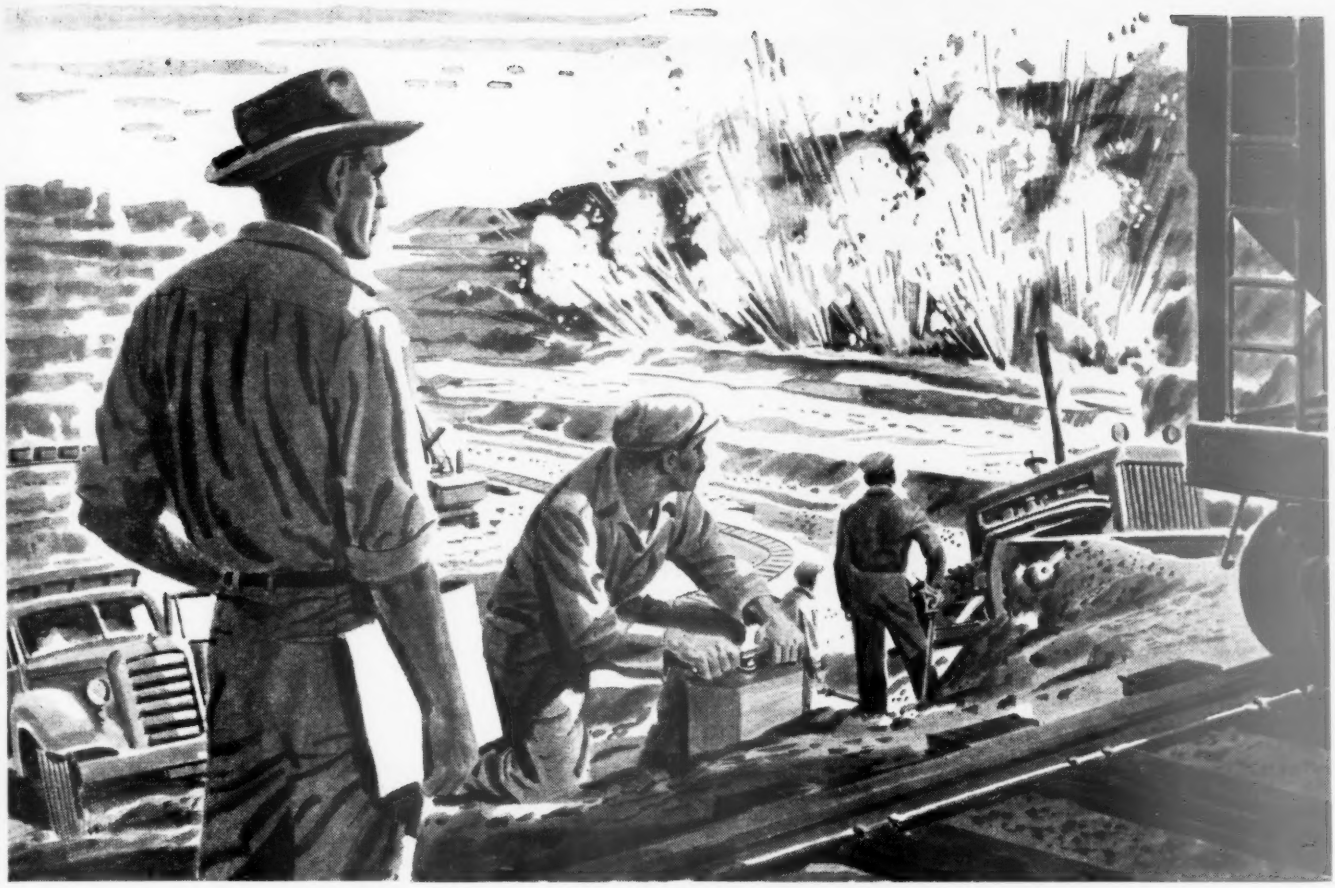

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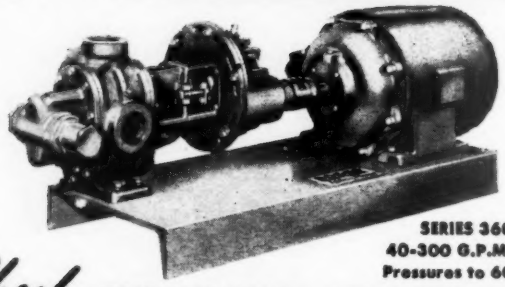

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Pressures to 60 P.S.I.

Check AND COMPARE THESE FEATURES

Compact . . . requires minimum of installation space.

Indoors or Outdoors . . . no pump house needed.

Gear Reduction . . . totally enclosed. Three gear ratios available.

Anti-Friction bearings throughout gear reduction.

Steel Bed Plate provides rigid foundation for pump and motor.

Operation . . . smooth and quiet; operates in either direction.

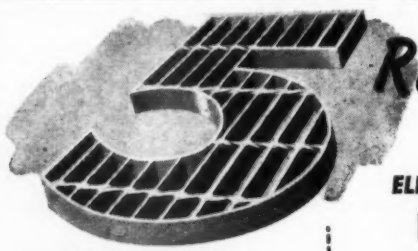
Suction Lift . . . up to 15 feet at 60 P.S.I.

Helical Gears . . . run in axial hydraulic balance.

SEE YOUR ROPER DISTRIBUTOR OR WRITE FOR CATALOG

GEO. D. ROPER CORPORATION
729 BLACKHAWK PARK AVE.
ROCKFORD, ILLINOIS

ROPER
Rotary Pumps



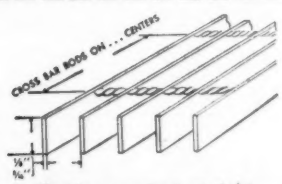
5 REASONS WHY
BLAW-KNOX
ELECTROFORGED® GRATING
IS YOUR BEST BUY

- STRENGTH
- SAFETY
- LOW UPKEEP
- LONG LIFE
- SELF-CLEANING

We factory-fit this one-piece Open Steel Flooring to your dimensions for easy installation. You can cover dangerous open areas and add useful space inside and out.

USE COUPON FOR DETAILS AND PRICES

BLAW-KNOX COMPANY
GRATING DEPARTMENT
BLAW-KNOX EQUIPMENT DIVISION
P. O. Box 1198, Pittsburgh, Pa.



Please send prices on_____sq. ft. Grating as per specifications marked at right.
Please send prices on_____Type_____Stair Treads_____inches wide.

COMPANY_____
INDIVIDUAL_____
STREET_____
CITY_____ZONE____STATE_____

BLAW-KNOX ELECTROFORGED STEEL GRATING

(N) INTERNAL HEAT EXCHANGER

An exclusive feature, available in all Farris nozzle and semi-nozzle safety relief valves, is an internal heat exchanger. This unit can be incorporated in the valve body without creating interference with the rest of the valve mechanism. The internal heat exchanger eliminates the necessity of steam tracing or steam jacketing a valve where highly viscous lading is encountered.

Circle letter (N) on reply card.

(O) PRESSURE INSTRUMENT

Supplementing American Meter Company's regular line of Series A-70 and A-88 mercury manometer orifice meters, a new metal bellows acuated differential pressure instrument, named the DRI-FLO Orifice Meter, has been placed in production by the company. The new units are offered for applications where accurate measurement is required without the use of a mercury manometer. They are adaptable to all American pneumatic controllers, transmitters, etc.

Circle letter (O) on reply card.

(P) VALVES, GAGES

In applying the Grove "Seal-O-Ring" principle to quarter-inch and half-inch valves for pressures of 3000 to 10,000 psi, Grove Regulator Company has introduced the Series T-2 Triport valves, and gage cocks. Resilient "O" ring seals are utilized in the seat assembly to provide bubble-tight shut-off for flow in either direction, as well as on the stem, to replace conventional stuffing box packing.

Circle letter (P) on reply card.

(Q) SELENIUM RECTIFIERS

A complete new line of air-cooled selenium rectifiers has recently been announced by Holcombe and Stearns, Inc. These H & S rectifiers offer practical and economical cathodic protection for pipe lines, cables, tanks and water systems. The new models incorporate many innovations of interest to the field man.

Circle letter (Q) on reply card.

(R) HYDRAULIC PUMPS

The Berry division of Oliver Iron and Steel Corporation announces the availability of its larger horsepower 32-10 series Rotodraulic hydraulic pumps, fluid motors, and transmissions. Designed in rotating piston design, these units may be used as either pumps or fluid motors interchangeability.

Circle letter (R) on reply card.

(S) FREE WATER KNOCKOUT

A new free water knockout for removing liquid water from natural gas lines has been developed by Oil Metering and Processing Equipment Corporation. The unit is designed with one single tube vessel and has simple rugged controls that assure satisfactory operation under the most adverse conditions. The free water knockout separates the free liquid water from the natural gas by means of gravity difference.

Circle letter (S) on reply card.

They Give...

PERMANENT PIPE-LINE SECURITY

From *Master* Craftsmen come the world's finest *FITTINGS* . . . drop forged from solid billets of specially blended *STEELS*.

Your pipe connections can be harmonious and lasting . . . even endure beyond the normal life of the system . . . if proper consideration is given the compatibility of their meeting. Many millions of feet of pipe and tubing have been brought together by W-S Double-Diamond Forged Steel Fittings in lasting unions against time . . . heat . . . pressure . . . turbulence . . . corrosion . . . oxidation . . . vibration . . . reduction and shock.

Such fortunate meetings withstand the adverse conditions of *ANY* service environments because W-S FITTINGS are inherently superior to those made by methods other than PRECISION MACHINING from solid FORGED stock.

Whatever your pipe or tubing application, you can profit from the permanence of W-S Double-Diamond (Screw-End and Socket-Weld) Forged Steel Fittings.

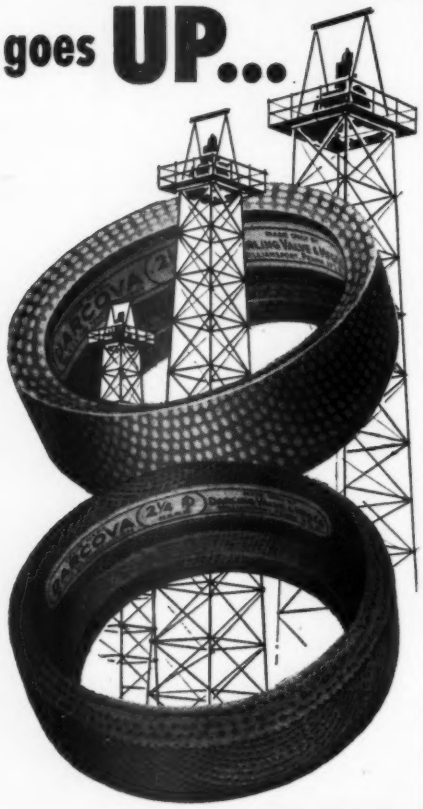
SOLD THROUGH LEADING DISTRIBUTORS

WATSON-STILLMAN FITTINGS DIVISION

H. K. PORTER COMPANY, INC.

127 ALDENE RD., ROSELLE, NEW JERSEY

Pumping Efficiency goes UP...



Costs go DOWN

WHEN YOU SPECIFY

DARCOVA

the original composition valve cup

No need to pull the well so often! Darcovas' precise control of all materials and processes from lab to well means exceptional resistance to wear and deterioration... Different textures, scientifically developed and controlled, are fully proved to give peak efficiency and longer flex-life at any depth! Precisely controlled sizes for any make or size pump increase efficiency.

Ask for genuine DARCOVAS at your supply store

DARLING VALVE & MANUFACTURING COMPANY

DARCOVA

WILLIAMSPORT 2, PA.

THE ORIGINAL COMPOSITION CUP

Trade Literature

Publication will be sent free.

(T) TORQUE CONVERTERS

Pacific Gear and Tool works has recently published a bulletin on Pacific-Western torque converters. Included are charts showing typical performance characteristics of a diesel engine and torque converter; an oil flow diagram; and cutaway drawings. The P-W converters automatically select proper torque requirements for each stage of the work. It acts as clutch geared transmission in starting and accelerating by multiplying engine torque loads from rest.

Circle letter (T) on reply card.

(U) RUBBER BEARINGS

A new catalog which describes the use and advantages of B. F. Goodrich Cutless rubber bearings in industrial equipment has just been published and is available through Lucian Q. Moffitt, Inc. The catalog contains engineering data of interest to plant engineers, product and equipment designers, and recommends the use of Cutless rubber bearings in various types of industrial equipment.

Circle letter (U) on reply card.

(V) PUMPING SYSTEM

Lufkin Foundry and Machine Company has published a 4-page bulletin on its hydraulic long stroke pumping unit. Included are flow diagrams of the hydraulic long stroke unit, as well as detailed explanation of the treversing principal and automatic counterbalance, and specifications.

Circle letter (V) on reply card.

(W) WELDING FITTINGS

The Ohio Steel Foundry Company has recently published a leaflet, Bulletin W-543, on its cast alloy butt welding fittings. Fittings are designed to insure maximum casting solidity and are hydrostatically tested, the company reports. Also described is the company's directional solidification principal designing so that metal sections taper uniformly.

Circle letter (W) on reply card.

(X) PORTABLE pH METERS

A four-page folder on Beckman portable pH meters—designed to simplify the choice of pH equipment—has been released by Beckman Instruments, Inc. Salient performance features and pictures distingnish the four pH meters in the series. They include a highly accurate instrument for laboratory and research studies; a line-operated model for routine measurements in the control laboratory, and two lightweight portables for plant and field applications.

Circle letter (X) on reply card.

(Y) SAFETY JOINT

An 8-page bulletin, profusely illustrated is now available from The Shaffer Tool Works. Described and illustrated is the Shaffer-Waggener bumper safety joint, a single tool that combines two methods of protection against stuck pipe. It incorporates a bumper sub and safety joint, and advantages over the regular single-purpose tools now available. With an outside diameter no greater than the tool joints, the Shaffer-Waggener bumper safety joint provides a rigid, wobble-free tool.

Circle letter (Y) on reply card.

(Z) PUMPING UNIT

A new eight-page bulletin has just been released by W. C. Norris Manufacturer, Inc., describing its Model CB-3-10 hydraulic long stroke pumping unit. Bulletin 36-A is well illustrated with line drawings and photographs showing in detail the design, installation, operation, performance and general specifications of the unit. Photographs showing field installations and the pumping conditions are of particular interest.

Circle letter (Z) on reply card.

(AA) GEARMOTORS

Elliott Company, Crocker-Wheeler Division, has introduced a new line of gearmotors featuring a wide selection of compact, integral power units with single (780 to 280 rpm), double (230 to 45 rpm) or triple (37 to 7.5 rpm) speed reduction. These units are available with any Crocker-Wheeler motor — A-C squirrel-cage, wound rotor, D-C or multi-speed, in open-protected, splash-proof, totally-enclosed non-ventilated, totally-enclosed fan-cooled and explosion-proof closures.

Circle letter (AA) on reply card.

(AB) PNEUMATIC CONTROLLER

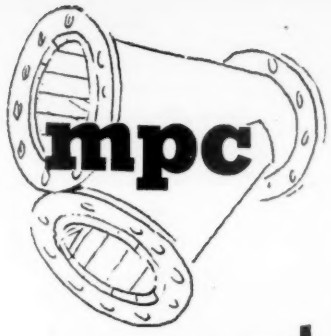
Recently announced is a new catalog No. 53-11 (4 pages) describing the new Fischer and Porter field-mounted P-4 Pneumatrol penumatic controller. The catalog shows a working sketch of this motion balance controller and includes diagrams of three-line and four-line field-mounted systems.

Circle letter (AB) on reply card.

(AC) HIGH TEMPERATURE ALLOYS

The H. M. Harper Company has just issued an informative bulletin on high temperature alloys such as Refractaloy, Discaloy, Inconel, Hastelloy alloys, A-286, etc., with a special section on Titanium. This bulletin contains data on these super alloys, together with a section on the characteristics of high temperature bolting. Tables give mechanical properties and chemical composition of various alloys.

Circle letter (AC) on reply card.



wood-lined steel pipe

. . . ideally suited for transporting brine; cuts desalting costs

Wherever salt presents a problem, MPC has the answer. MPC Wood-Lined Steel Pipe is unexcelled for the transporting of salt solutions and salt bearing crudes. Its resistance to corrosion reduces upkeep and downtime on desalters, substantially reducing costs.

Whether your problem involves salt solutions or sour crudes containing hydrogen sulphide or other corrosives, you'll find the practical, economical answer in MPC Wood-Lined Steel Pipe. Rated for service up to 180°F. and 250 p.s.i. Higher pressure ratings for special service requirements. All pipe is flanged and available in 10' and 20' standard lengths or "tailor-made" to your specifications. Wood-lined steel fittings available in standard and special designs.

CATALOG AVAILABLE. For additional information write Application Engineering Department.

mpc **MICHIGAN PIPE COMPANY**
Bay City, Michigan

Manufacturers of Wood-Lined Steel, Saran Rubber-Lined Steel, Stainless Steel and Monel Piping. Represented nationally by Saran Lined Pipe Co. Detroit, (Ferndale) Michigan.

(AD) TAPER-LOCK SPROCKETS

In Dodge Manufacturing Corporation's new 24-page, 8½ × 11 bulletin the man who selects, specifies or buys roller chain and sprockets will find all the data required. One page is devoted to taper-lock sprockets for each size of chain from No. 40 through No. 100 inclusive. Each page includes: Cross section drawing, dimensions, number of teeth, list prices with and without bushings, sprocket number, bushing number, maximum stock bore, etc.

Circle letter (AD) on reply card.

(AE) DEAERATING HEATERS

A new bulletin on spray-type deaerating heaters has just been published by Graver Water Conditioning Company. The bulletin explains the specific functions and requirements of deaerating heaters, describes their design and operation in detail, and outlines the accessory equipment for best results.

Circle letter (AE) on reply card.

(AF) LIQUID POLYMER-EPOXY RESIN

Preliminary formulas and applications for liquid polymer-epoxy resin combinations have been assembled in a portfolio by the Thiokol Chemical Corporation. Formulas and physical characteristics are given for combinations of Thiokol with such epoxy resins as Bakelite's BRR 18794, the Ciba Company's "Araldite," CN 503 and Shell Chemical's "Epon" 828. Compounded with these epoxy resins are Thiokol Liquid Polymers LP-3 and LP-33.

Circle letter (AF) on reply card.

(AG) CONTROL UNIT

A four-page folder illustrating and describing the new Baker power control unit, PCU-75, has been released for distribution by The Baker Manufacturing Company. Performance details are given on the completely new design features of the PCU-75's multiple-disc clutch, simplified brakes, adjustable hand levers, and sheave mountings.

Circle letter (AG) on reply card.

(AH) JUNK CATCHER

An illustrated folder showing the features and advantages of the Globe "2 in 1" junk catcher has recently been completed by Globe Oil Tools Company. Developed after extensive research, the Globe junk catcher is now available with a magnet-type catcher which is interchangeable with the regular catcher.

Circle letter (AH) on reply card.

(AI) HARD-FACING

A comprehensive and analytical study of hard-facing, its application and its wear-resisting qualities wherever impact and abrasive conditions exist, is contained in a new 52-page brochure published by the Mir-O-Col Alloy Company. This report incorporates the latest data and instructions on hard-facing, as well as new information about Mir-O-Col's own line of hard-facing metals.

Circle letter (AI) on reply card.

WELDING IDEA SPEEDS PIPE-GANG PRODUCTION 30 PERCENT

By **Mr. Clyde Wyant**
Midwestern Constructors
Tulsa, Oklahoma

BY having three welders work together on stringer-bead welding and three welders on hot passing, pipe-gang production has been boosted 30% on the Transmountain Oil Pipe Line. The pipe, 24″ in diameter and bevelled 60 degrees, is manually welded with three passes of Lincoln "Fleetweld 5" electrodes using Lincoln "Shield-Arc" engine driven welders. Welds, x-rayed for examination, are found to be of uniform top quality throughout the spread.

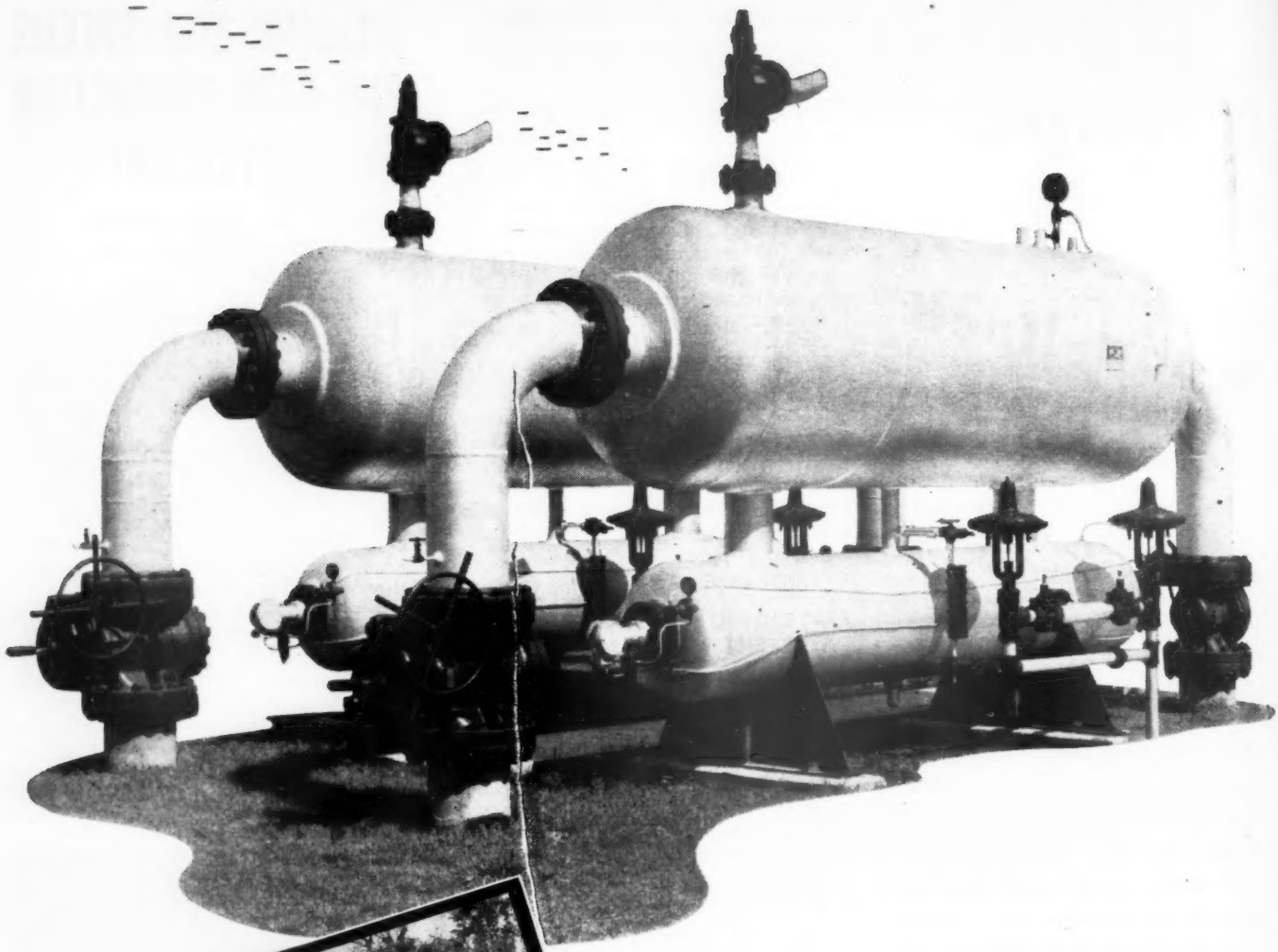
The three-man method used on this line was originally developed on Midwestern's spread for the Texas Illinois Natural Gas Pipeline where 4 stringer-bead and 4 hot-pass welders worked together as a team. On the Transmountain Line, however, three-man teams were used since the progress was limited to clearing of the right-of-way.

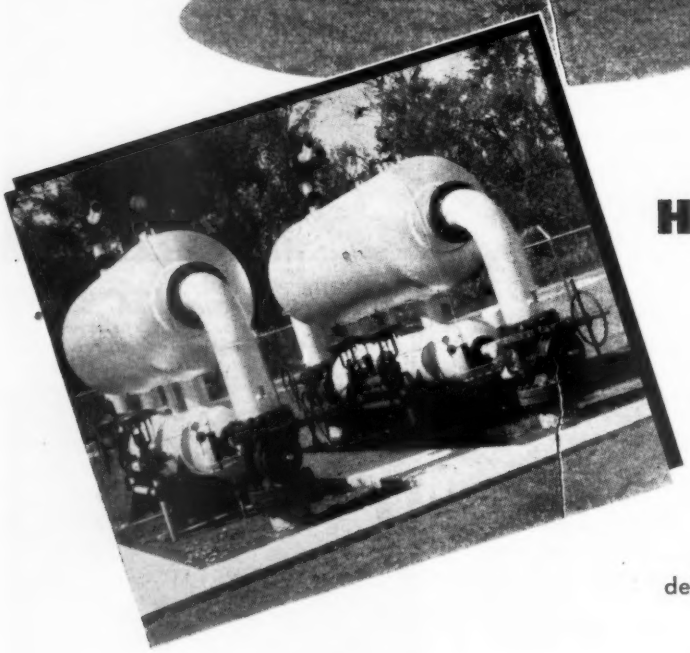
ON THE LINE *Spread No. 3 Transmountain Oil Pipe Line. 77 Lincoln "Shield-Arc" engine driven arc welders speed pipe laying operations 30% using three-man team method developed by Midwestern Constructors Inc., Tulsa, Oklahoma.*

QUALITY WELDS *produced 30% faster are made with Lincoln "Fleetweld 5". Joints x-rayed for inspection are found dense and uniform in quality.*

LATEST PROCEDURES, SPEEDS AND COSTS for welding pipelines are given in the Lincoln "Procedure Handbook of Arc Welding Design and Practice". Price only $2.00 postpaid in the U. S. A.; $2.50 elsewhere. Write Dept. 2808.

THE LINCOLN ELECTRIC COMPANY
Cleveland 17, Ohio
THE WORLD'S LARGEST MANUFACTURER OF ARC WELDING EQUIPMENT





NATIONAL
HORIZONTAL SCRUBBERS
condition gas at Westwego Installation

These two 48" x 10' x 500# WP National Horizontal Gas Scrubbers are installed at the Westwego station of the world's largest handler of natural gas. They are efficiently and economically removing liquids, both water and hydrocarbons, to assure the delivery of clean, dry gas to consumers in the New Orleans area. National Horizontal Gas Scrubbers are available in a wide range of sizes, working pressures and capacities to fit the needs of gas producers and carriers.

It's a National

NATIONAL TANK COMPANY

TULSA, OKLAHOMA

9-8-52